Chemical Engineering Progress

JULY 1955

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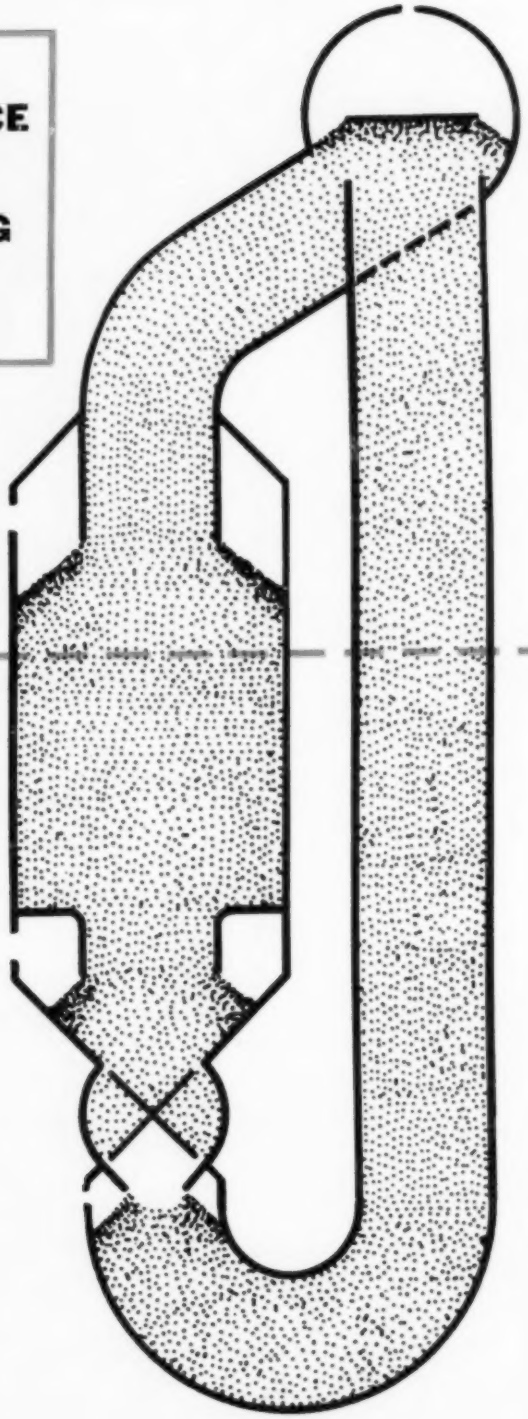
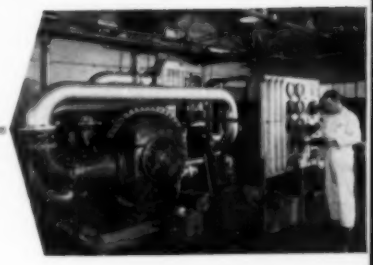


EQUIPMENT

in principle and practice



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Chemical Engineering Progress

JULY, 1955 • Volume 51, No. 7

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this month's cover

Process equipment is symbolized to attract attention not only to the several articles, appearing in this issue, but also to the new Data Service.

—cover by Milton Wynne Associates.

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For a brief description of each article . . . see "What's In This Issue"—page 33

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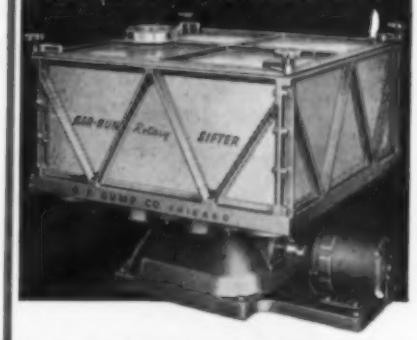

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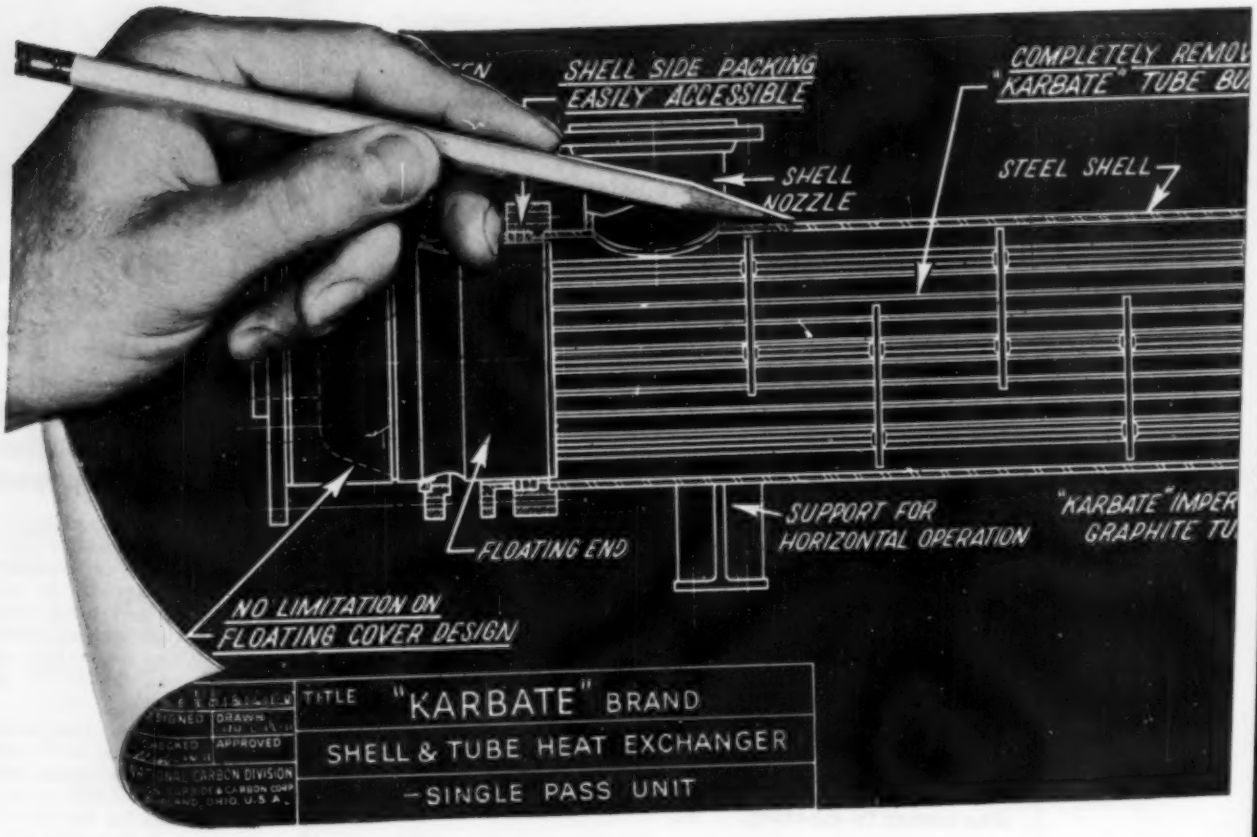

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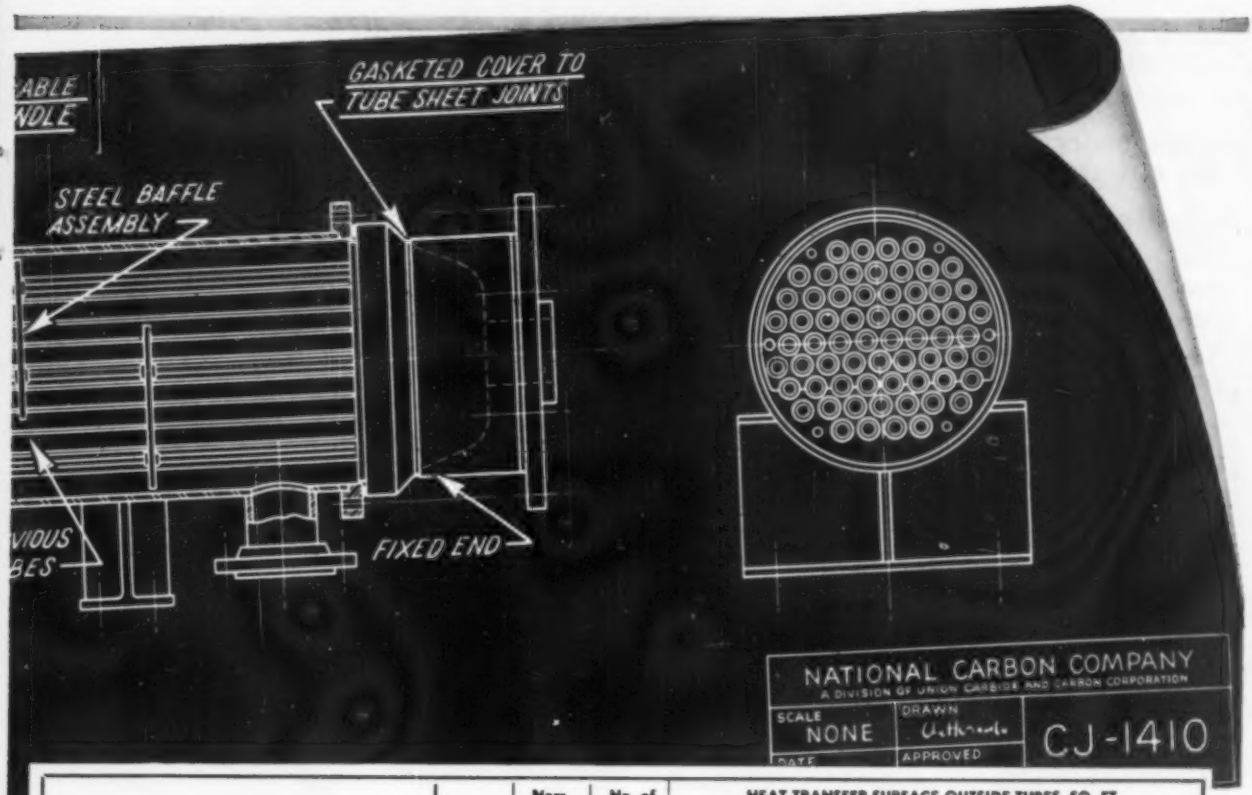

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90	6"	9	17.7	26.5	—	—	—
310	10"	31	—	91.2	121.6	141.9	162.2
420	14"	42	81.7	123.3	164.8	192	220
640	16"	64	124.3	187.7	251	293	335
850	18"	85	165.2	250	334	389	444
1090	20"	109	213	320	427	499	570
1350	22"	135	263	397	530	618	706
1630	24"	163	317	479	640	746	852
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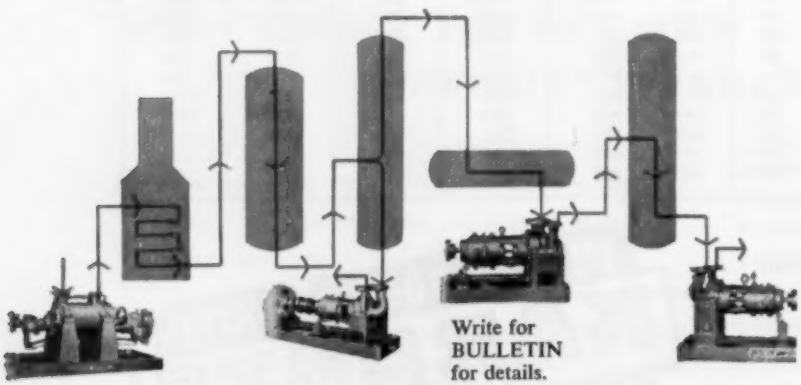

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LETTERS TO THE EDITOR

Professionalism and the Public

I have read with great interest Dr. Dinsmore's article "The Chemical Engineer and the Public." Like any other member of the profession I want to see us receive the proper recognition from the public.

But while the engineer working in a group deserves as much recognition as the doctor, lawyer, and minister, can he expect to receive this recognition on the same basis as these individuals who "act as self-controlled units." The actions of the latter are subject only to their own judgment and thus represent their personal professional standards.

On the other hand, engineers working in groups are frequently unable to make a choice as to the direction of their work. To be sure, they will observe the highest personal integrity in carrying out their work But that does not necessarily mean working for the best interest of the public. Their efforts are much too frequently controlled by what the sales department can sell best at a profit. In the automotive industry, for example, is the public best served by more and more horsepower, or would not the engineer serve the public better by devoting his efforts to working on safety features to save lives and economy to conserve our natural resources?

Should an engineer quit his job whenever he feels his efforts are not directed towards the public good? The answer to this question is obviously "no," except, of course, in extreme cases.

But the engineer can serve the public by putting his training to use in the community outside his work. Just as engineering training has been found to be a good basis for executive positions, engineers should be able to excel in serving their community, individually as civic leaders or in professional groups.

GUNTHER H. BALDAUF

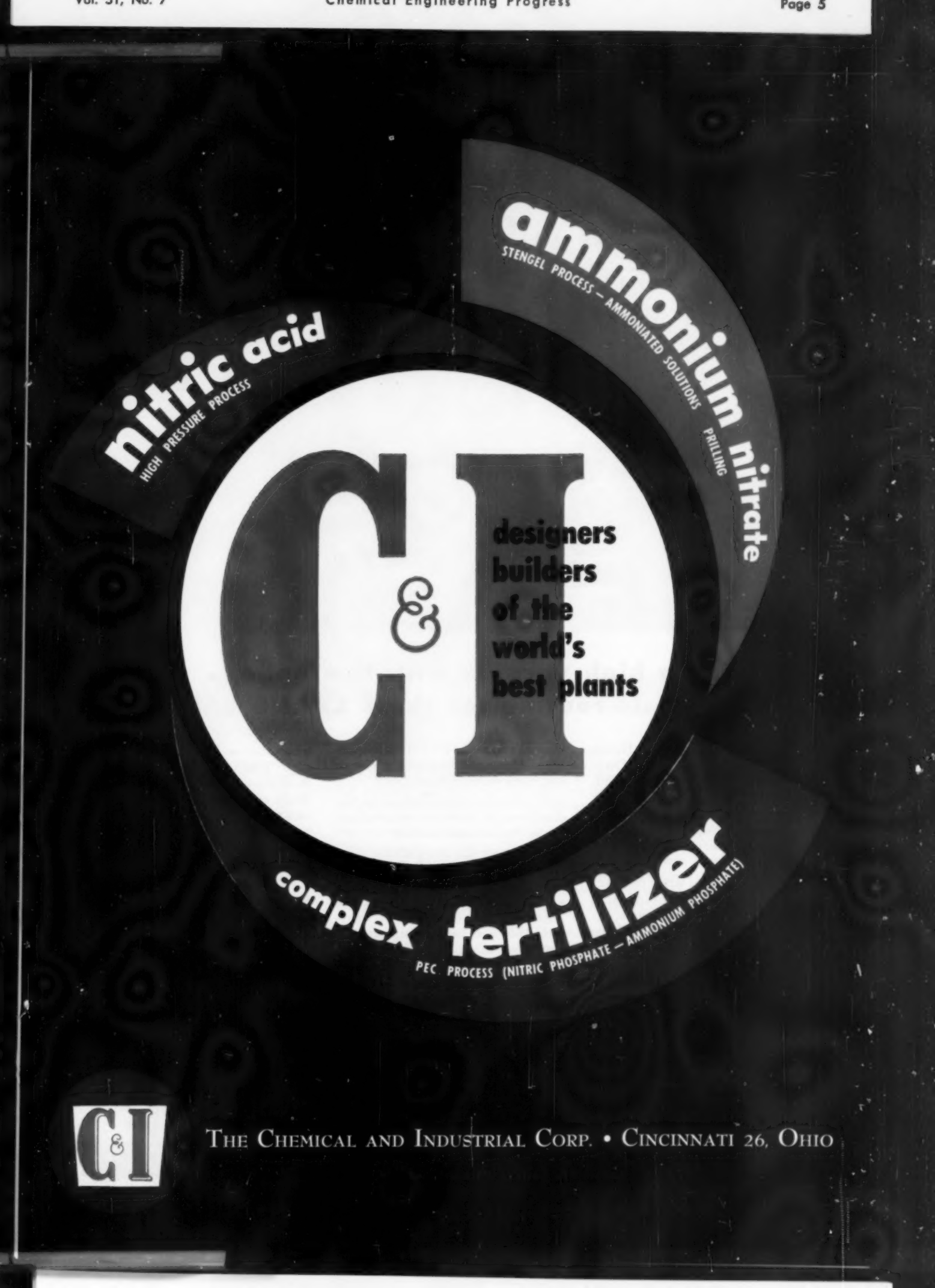
Brevard, N. C.

At our suggestion Dr. Dinsmore has made the following reply:

It seems to me that the question raised is whether or not an engineer employed by a company and working as one of a group of engineers, is morally responsible to the public for the design features of the products sold by his company.

Actually, the determination of these features, assuming that they are commercially feasible, is not a question of engineering judgment. It is a matter of sales opinion as to what characteristics will best meet the demands of the buying public. Mr. Baldauf is quite right in saying that the motivation of sales execu-

(*Continued on page* 10)



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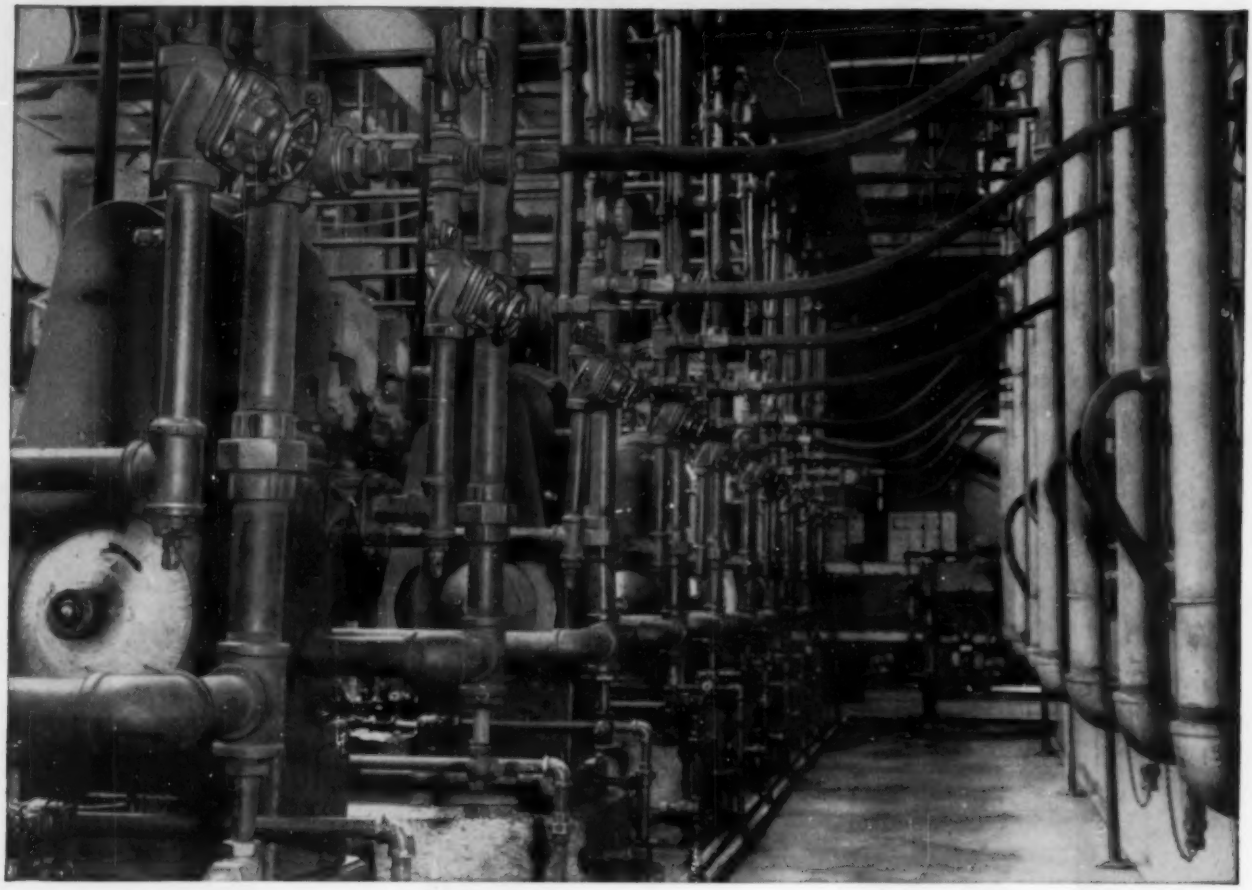

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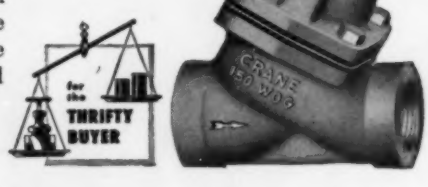

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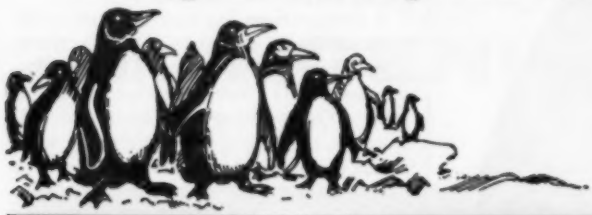

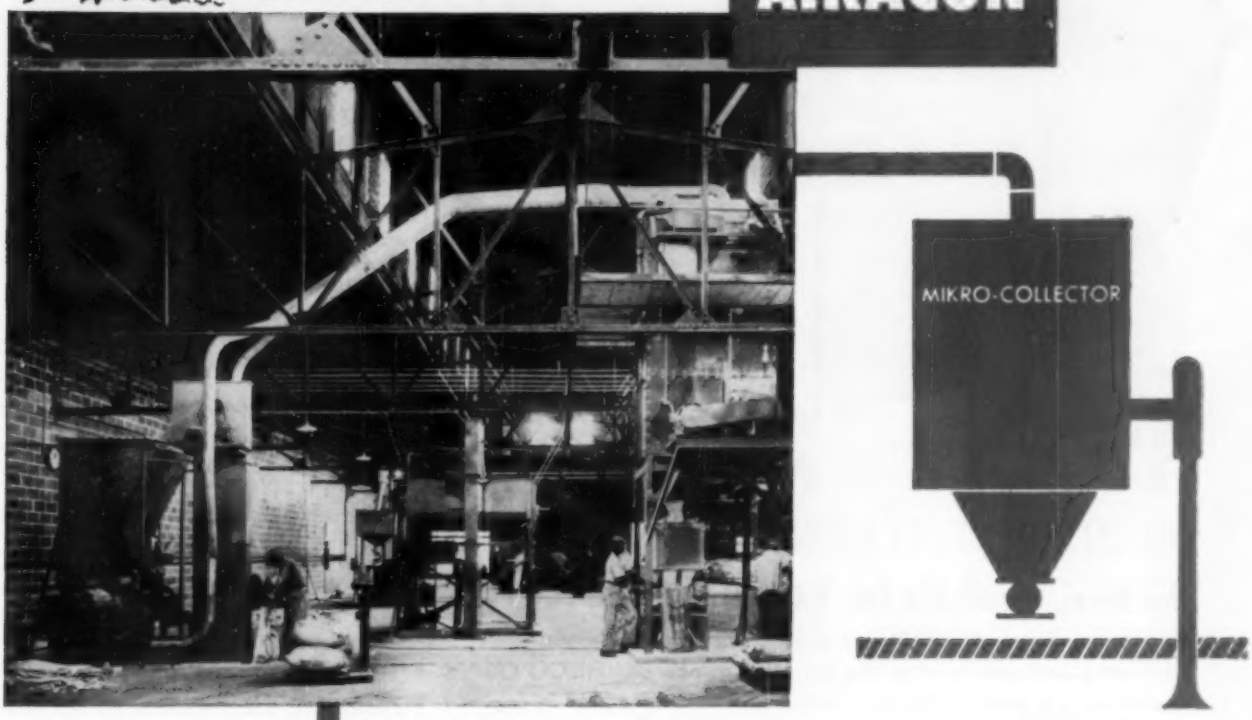

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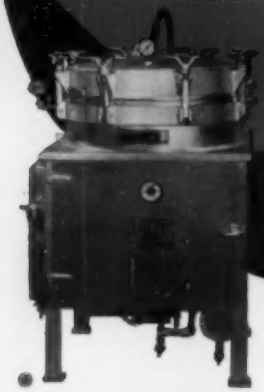

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LETTERS TO THE EDITOR

(*Continued from page 6*)

tives is to put out that article which they believe will sell best at a profit. This is not an engineering decision.

A conscientious engineer will not work for an employer who makes illegal products or those which may trap the unwary into causing bodily harm to themselves or others. On the other hand, he cannot and, I believe, should not, try to determine what is best for everybody and refuse his services to any that do not meet this ideal. One need only think of refusal to work for a sugar refiner, because eating too much sugar makes some people fat, to see that such a policy would be impractical.

One must be careful to separate functions when comparing a professional man who is an individual operator with one who works for an employer.

In the first instance, there are "management" functions which are necessarily assumed by the professional man, because there is no one else to take care of them. They are, among others, economic, planning of schedules, client (customer) contacts, legal, etc. They are identified with professional conduct because they are inseparably connected with an individual who, himself, supplies professional services.

In the second instance, the professional man is "on the management team" or "identified with management" only in those management areas where his strictly professional skills and experience are applicable. Beyond this he tends to move out of the professional sphere into the purely management territory.

This analysis could well be expanded with numerous illustrations. It is not sophistry. It simply points to the fact that a professional man should not try to sell services under the guise of his professional label, for which his training and experience as a professional, do not fit him. He should make it clear that if he steps beyond this type of service, he steps without his professional sphere. Likewise, he need feel no professional responsibility for the judgment of others, associated with him, who control matters outside that sphere. Outrage to his moral feelings, is a personal—not a professional matter.

R. P. DINSMORE

Akron, Ohio

For Readers' Information

On p. 64 of your April 1955 issue, you state that, with respect to reactor fuel to be made available to industry (presumably "private industry" is meant), the A.E.C. has set a maximum enrichment of 20% U-235 by weight. This disagrees with other information which I have received, which indicates that the above figure applies to "foreign installations" only (as under the "atoms-for-peace" plan), and that

(*Continued on page 18*)

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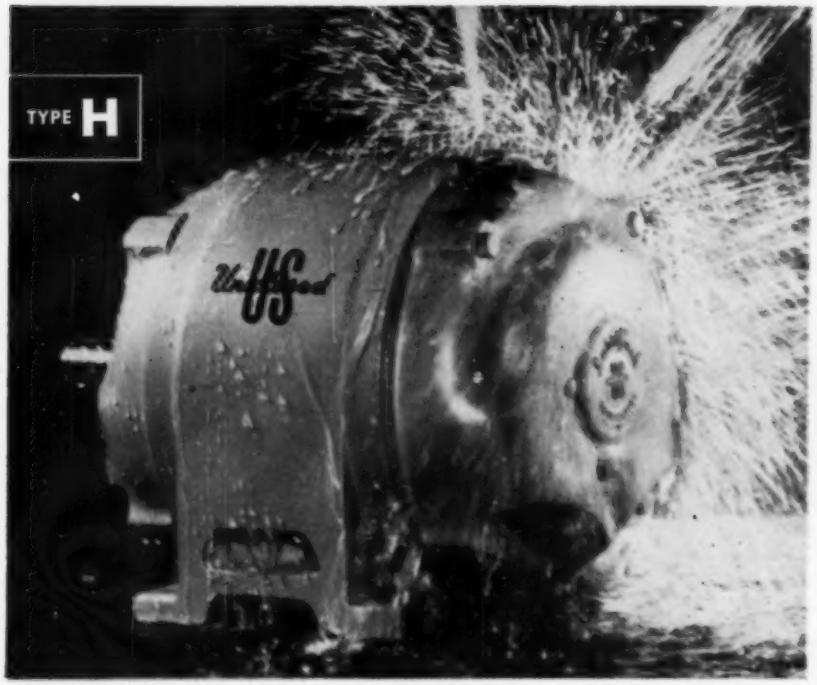

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AT EACH END OF THE MOTOR DIRECTS AIR AND DEFLECTS WATER... Ventrifoil, a specially formed deflector, directs air around bearing housings and into fans on the rotor. By forming a "vestibule" between the bracket openings and the fan inlet, water is deflected and separated from the air stream without hindrance of the air flow to interior.

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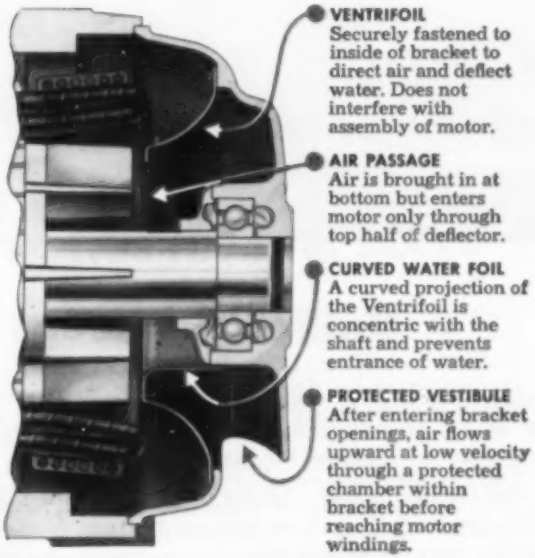
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Securely fastened to inside of bracket to direct air and deflect water. Does not interfere with assembly of motor.
AIR PASSAGE
Air is brought in at bottom but enters motor only through top half of deflector.
CURVED WATER FOIL
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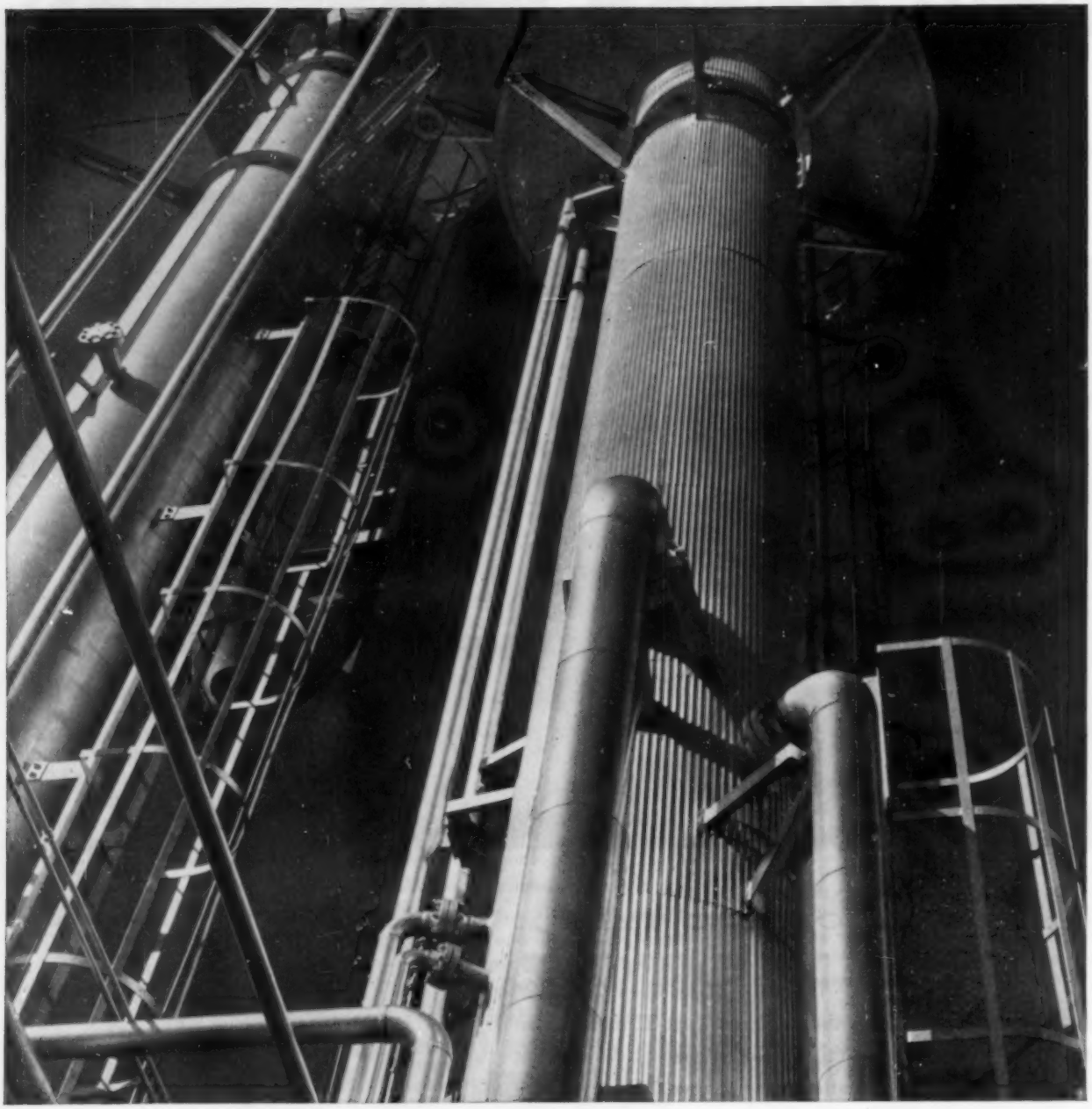


Unibestos® keeps 1175° where it belongs

Catalytic cracker...vacuum still and "poly" plant—all get added protection against heat loss with strong, single-layer Unibestos Pipe Insulation.

And Unibestos starts cutting costs right at the beginning. Unibestos, made of African Amosite, is easy to handle, easy to cut and miter. Long, interlacing fibers assure positive heat seals between sections...reduce pointing of joints...simplify insulation of fittings.

Built to resist thermal shock, vibration, and unaffected by most acid and chemical fumes, Unibestos can be easily removed and effectively reapplied when lines are relocated or replaced.

• Standard Production Sizes

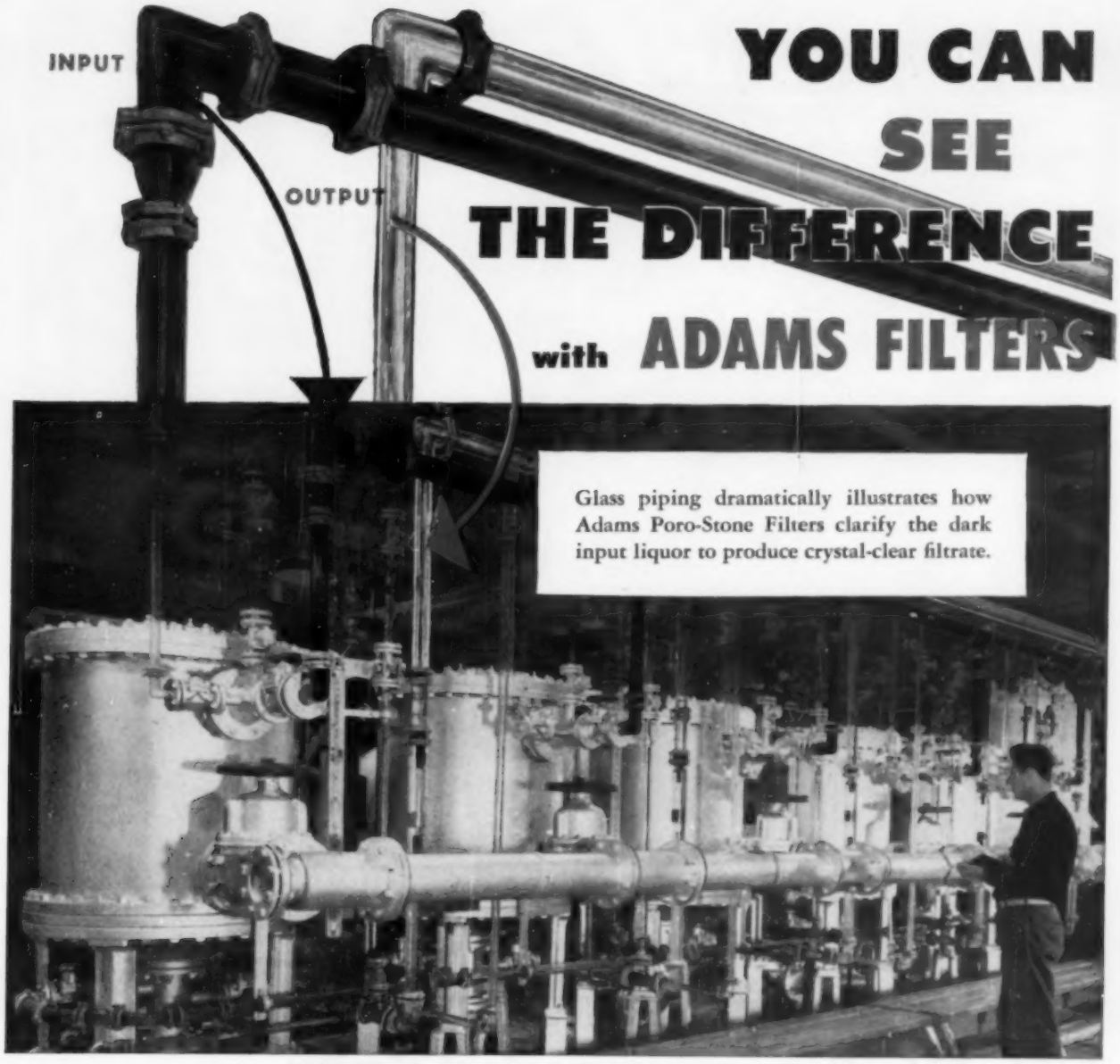
Unibestos Pipe Insulation is regularly made in 3-foot lengths for pipe sizes from ½″ through 24″, in standard thicknesses through 5″. Unibestos Block Insulation is made in 6″, 12″, 18″ or 36″ widths and in thicknesses from 1″ through 3″ in ½″ increments.

For complete information, write for descriptive Bulletin 109C

UNARCO®

UNION ASBESTOS & RUBBER COMPANY

1111 West Perry Street • Bloomington, Illinois



YOU CAN SEE THE DIFFERENCE with ADAMS FILTERS

Glass piping dramatically illustrates how Adams Poro-Stone Filters clarify the dark input liquor to produce crystal-clear filtrate.

Dramatic Results with ADAMS Poro-Stone Filters at BECCO

Efficient filtration is a critical process requirement in the electrolytic preparation of hydrogen peroxide. Thus at the Buffalo plant of the BECCO Chemical Division, Food Machinery and Chemical Corporation, the most effective filtration equipment was vitally necessary.

Finely divided iron compounds are precipitated during purification of the cathode liquor. This precipitate must be completely removed before recycling the filtrate to the cells to insure high process efficiency and ultimate product purity.

Adams Filters with inert Poro-Stone media were chosen for this critical filtration process in the initial installation. Rubber lined construction and glass piping were also specified to prevent any possibility of product contamination.

Increasing demand for BECCO high-purity peroxide made additional production facilities necessary in 1949 and again in 1951, plus another installation in their new west coast plant. On the basis of their excellent performance, Adams Poro-Stone Filters were specified in each case.

Do you have any filtration problems in your process? Our Engineering Department will be glad to be of help. For general information on Adams Chemical Filters write for a free copy of Bulletin 431.

R. P. ADAMS CO., INC.
240 E. PARK DRIVE BUFFALO 17, N. Y.

Celite Filtration assures perfect clarity—

adds eye appeal and buy appeal to food products

TO GIVE foods and beverages that extra quality which results in more sales appeal, leading processors depend on Celite Filtration. The Celite method provides perfect clarity at high production rates.

Celite Filtration is *efficient*. It removes even the finest suspended solids. Moreover, Celite Filtration is *economical*. It may be used with any type of conventional filter, it is almost automatic, and only unskilled labor is required for routine operation.

And Celite Filtration is *flexible*. To meet your specific requirements, Celite comes in nine standard grades of microscopically controlled particle size. The right balance between degree of clarity and rate of flow may be easily controlled. You can obtain perfect clarity in food products—highest purity in antibiotics—complete removal of insoluble impurities from water, petroleum, chemicals, dry cleaning solvents and many other liquids.

A Johns-Manville Celite Filtration Engineer will gladly discuss the advantages and use of Celite in your product or production process. For his services, without obligation, write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CELITE INDUSTRY'S STANDARD FOR FINEST FILTRATION

PEAK PERFORMANCE

The production experience of virtually every major chlor-alkali producer in America proves that dependable GLC ANODES may be relied upon for peak performance.

ELECTRODE GLC DIVISION

Great Lakes Carbon Corporation

GRAPHITE ANODES, ELECTRODES, MOLDS and SPECIALTIES

ADMINISTRATIVE OFFICE: 18 East 48th Street, New York 17, N.Y.

PLANTS: Niagara Falls, N.Y., Morganton, N.C.

OTHER OFFICES: Niagara Falls, N.Y., Oak Park, Ill., Pittsburgh, Pa.

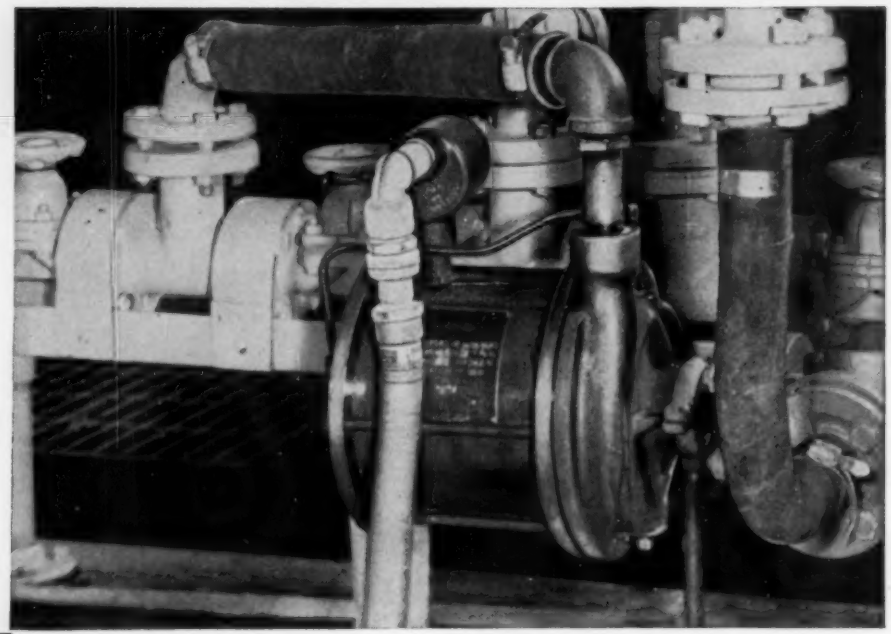
SALES AGENTS IN OTHER COUNTRIES: Great Northern Carbon & Chemical Co., Ltd., Montreal, Canada
Overseas Carbon & Coke Company, Inc., Geneva, Switzerland; Great Eastern Carbon & Chemical Co., Inc., Chiyoda-Ku, Tokyo, Japan

No seals
No stuffing box

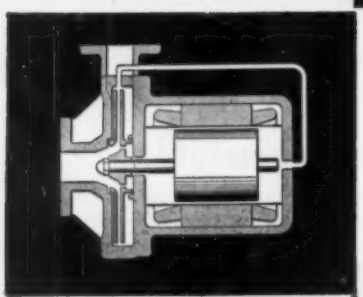
Chempump

now used
in plating operations

at Western Electric Company



Leak-proof *Chempump* installed on 270-gallon plating machine at Western Electric Co.'s Allentown, Pa. plant. Seal-less unit pumps 10 gpm of solution at 155°F against a head of 35 ft.



Chempump combines pump and motor in a single hermetic unit. Pumped fluid enters rotor chamber; no shaft sealing device required.

Approved by Underwriters' Laboratories. Available in wide choice of materials . . . from ⅓ to 7½ hp. Capacities to 250 gpm. Heads to 195 feet.

Chempump can't leak!

Gold plating tolerances at Western Electric's Allentown, Pa. plant are appreciably closer than in most precision plating operations. Holding these tolerances requires frequent checks on bath composition, and careful filtering and agitation of the plating solution. Selection of a leak-proof *Chempump* for this gold plating operation solves several problems. Since *Chempump* has no seals, no stuffing box, there can be no leakage of costly gold solution. Absence of any packing or other internal lubricants means complete freedom from plating solution contamination, which would seriously impair plating uniformity and product quality.

The *Chempump* runs 16 hours a day, 5 days a week. Every four months the rear bearing is replaced; the front bearing, much less often. The job takes about 20 minutes. *No other maintenance is required!*

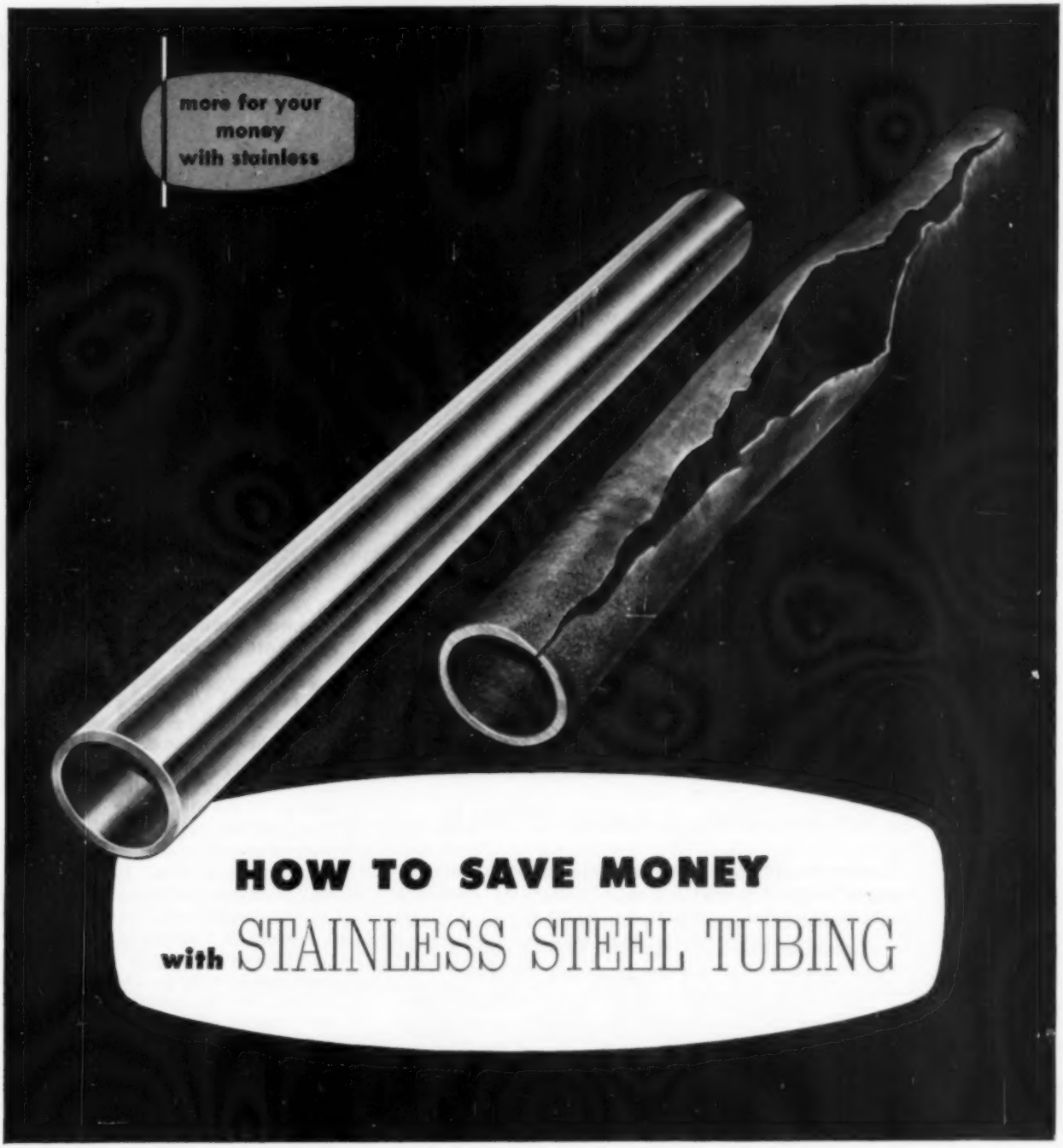
Your process, too, can benefit with *Chempump*—the seal-less centrifugal pump that can't leak. Send for new 16 page Bulletin 1010 and get the details. Chempump Corporation, 1300 E. Mermaid Lane, Philadelphia 18, Pa.

Engineering representatives in over 30 principal cities in the United States and Canada.

Chempump —first in the field...process-proved

Proved by ... of SERVICE

LETTERS TO THE EDITOR



Downtime and the labor cost of replacing worn-out tubing made of common materials can be a great deal more expensive than the extra first cost of long-lasting stainless.

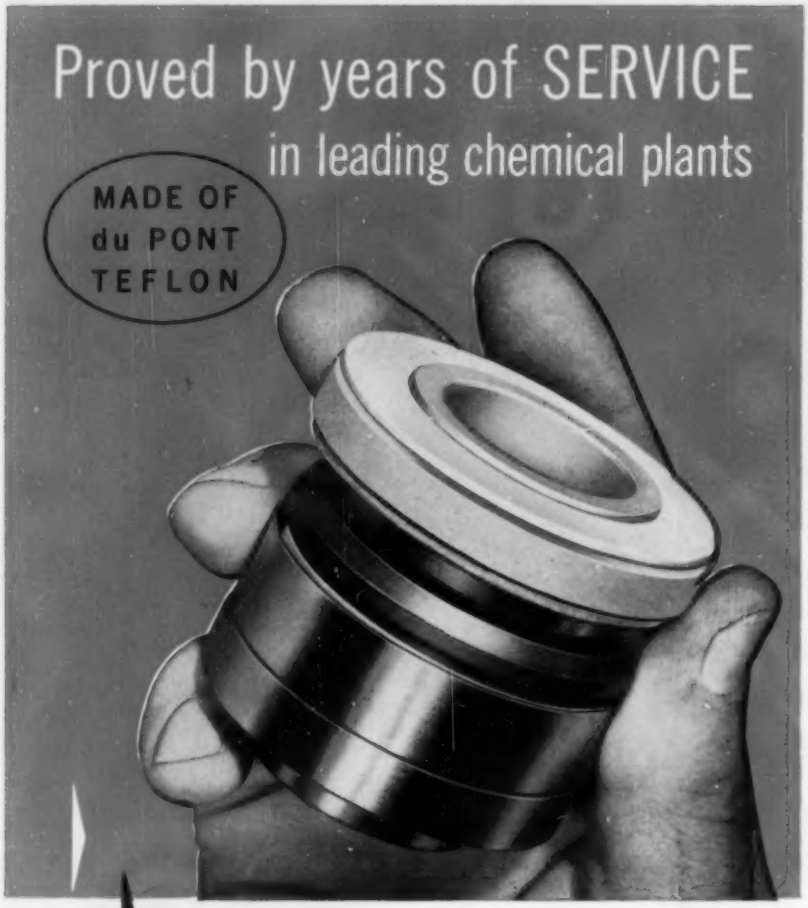
The tube failure pictured is a dramatic reminder of the indeterminate, and usually shorter, service life of tubing which may bear a smaller price tag, but whose *total* cost can be measured only after the ravages of time and corrosion have tested its durability.

For optimum strength, corrosion resistance and oxidation resistance, there's a stainless grade, size, heat treatment and finish best suited to your particular pressure and temperature requirements. Ask Mr. Tubes, your link to B&W, how to get more for your money with stainless. *Or write for Bulletin TB-356.* CEP.

B&W
TUBULAR PRODUCTS DIVISION

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa. and Milwaukee, Wis.: Seamless Tubing, Welded Stainless Steel Tubing
Alliance, Ohio: Welded Carbon Steel Tubing
Milwaukee, Wis.: Seamless Welding Fittings

TA-5038(P)



CHEMISEAL SHAFT SEALS

Customers report unsurpassed performance and much longer life under a wide variety of chemical service conditions, with Chemiseal Mechanical Seals.

A superior material—duPont TEFLON, and a one-piece balanced bellows design are responsible.

Chemiseals rotate with shaft. Only bearing surface is between precision ground stationary and rotating faces—the latter being an integral part of the TEFLON bellows unit.

Advantages include: Applicable to all chemical requirements, including clear, abrasive and tarry materials. Seal drop-tight and stay tight. Low friction load on shaft. No scoring of shafts—shafts already scored can be satisfactorily sealed. Pressures at the seal to 100 psi at 75° C or 75 psi at 100° C. Standard sizes ⅛" to 2⅛". Other sizes on special order. Over-all length 2½".

Write for Bulletin No. MS-954.

UNITED STATES GASKET CO., Camden 1, N. J.

U S G

FABRICATORS OF FLUOROCARBONS AND OTHER PLASTICS

Representatives in principal cities throughout the world

LETTERS TO THE EDITOR

(*Continued from page* 10)

domestic private industry may receive more highly enriched uranium. Could you clarify this point for me?

LEON DAVIDSON
Nuclear Development Associates, Inc.
White Plains, N. Y.

According to a recent communication from R. L. Southwick, Acting Chief, Public Information Service, Atomic Energy Commission, the maximum enrichment of 20% U-235 applies to material for shipment abroad, and no limit is placed on enrichment of uranium for licensed private users.

EDITOR

NOTED AND QUOTED

"Human Fundamentals" in No Synthetic Form

Well, luck does play some part in human events, of course. Associations and contacts are valuable assets which should be cultivated. But winners, whether in sports or in life, are usually those who have the ability to take advantage of the breaks when they occur. "Contacts" are important only when the association offers a mutual benefit of interest to both sides. The "right people," otherwise, soon turn out to be the "wrong people."

Nor can he progress by the hypocritical process of flattery or by catering to some special conceit. Such devices are obvious and transparent; they fool no one—least of all his boss, who is on the lookout for such maneuvers.

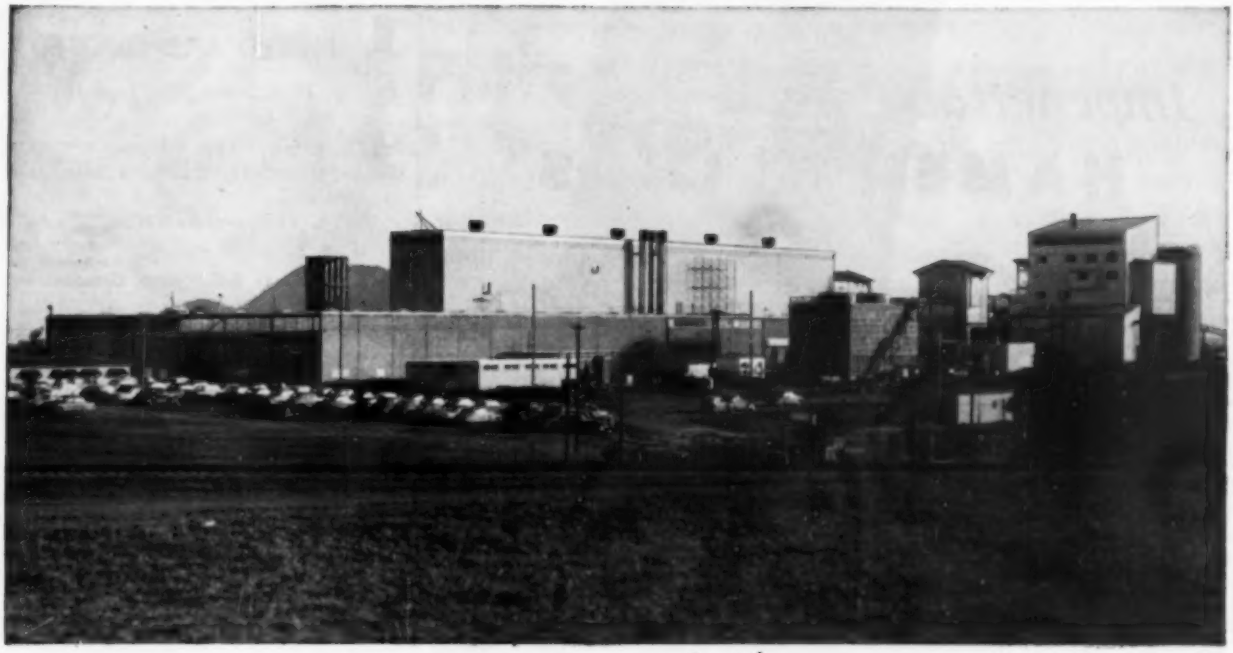
No, when the real story is analyzed, the successful man is the one who has climbed the ladder through proving to his successive bosses that he has something to offer—that he has what it takes. Performance is the only real basis of achievement.

It is not an easy way to success. I don't know of any easy way, but it is the most direct and sure way.

When we see a successful man, we can be certain that he has made a hit with his bosses all along the line. So, if we are to learn from his experience, the problem is to find out what it was that enabled this man to make a hit with his boss.

Was it luck? Was it because he had a pleasant personality? Or was it because he had something to contribute that caused the boss, in the way of

(*Continued on page* 20)



Lithium

Putting the "prod" in production . . .

Here's a bird's-eye view of the biggest step yet in meeting industry's continuing demand for Lithium. Lithium Corporation has put on stream a lithium plant with the largest potential capacity in the world. The $7,000,000.00 project located at Bessemer City, North Carolina is producing Lithium Carbonate and Lithium Hydroxide for industry at large.

Unique in the Lithium industry, Bessemer City is processing run-of-mine ore directly through its chemical plant, as well as concentrates. The former eliminates the once necessary step of first concentrating the ore. The plant treats company-owned deposits of spodumene ore reserves in the adjacent King's Mountain area. The concentrates are from Canadian sources. Coupled with the company's original plant at St. Louis Park, Minnesota, a substantial increase in present productive capacity of the lithium industry is assured.

• • •

Why don't *you* look into Lithium? This miracle element is benefiting, cost-wise, many important industries. Organic chemicals, ceramics, air conditioning, greases, metallurgy, pharmaceuticals, brazing fluxes —all utilize Lithium to improve their products. It might well contribute untold profits for *your* company. A card or letter will bring you complete information.

. . . trends ahead in industrial applications for Lithium.

LCA LITHIUM CORPORATION OF AMERICA, INC.
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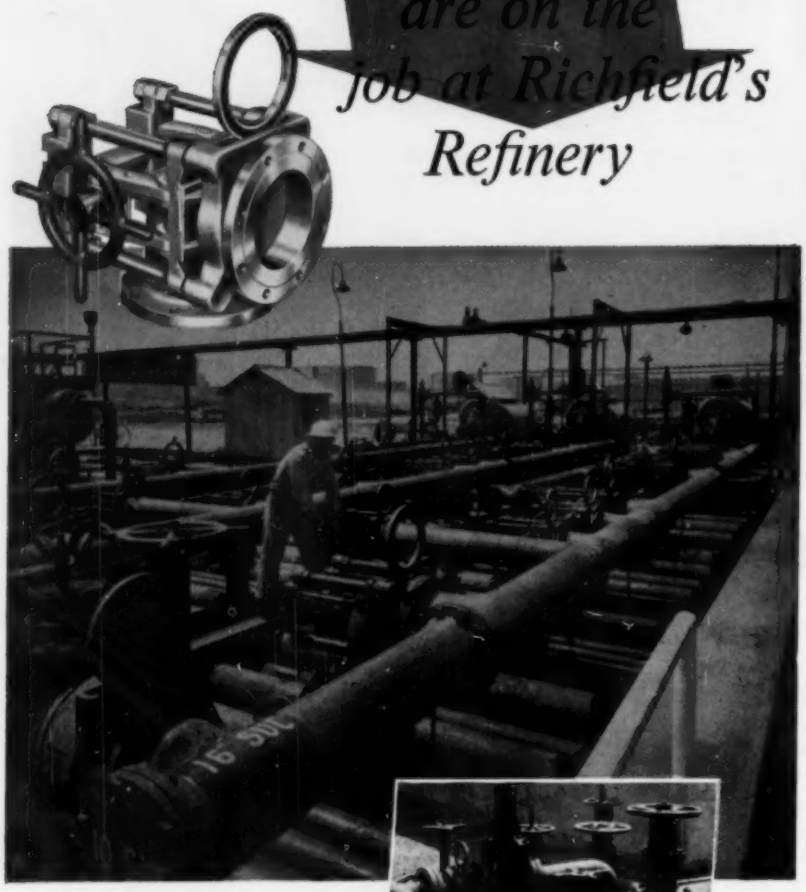
MINES: Keystone, Custer, Hill City, South Dakota • Bessemer City, North Carolina • Cat Lake, Manitoba • Amos Area, Quebec • BRANCH SALES OFFICES: New York • Chicago
CHEMICAL PLANTS: St. Louis Park, Minnesota • Bessemer City, North Carolina • RESEARCH LABORATORY: St. Louis Park, Minnesota

Impenetrable Sealing
HAMER BLINDS
are on the job at Richfield's Refinery



After testing their action in a trial installation, Richfield now uses Hamer Line Blinds extensively at its refinery at Watson as illustrated above.

HAMER *Visible Shut-off* LINE BLIND VALVES

HAMER *Plug Valves*

Thousands of users have proven the easy and immediate operation of Hamer Plug Valves. Will not stick or freeze.

Refinery operations require a valve that will provide a continual leakproof line shutoff. Hamer Blinds with their foolproof sealing action are unsurpassed for providing an absolute line seal that's both positive and permanent. In addition, Hamer Blinds fast, one minute, one man operation literally pay for their cost in downtime saving.

Send for FREE Catalog

HAMER VALVES, INC.

2919 Gardenia Ave., Long Beach 6, Calif.

Representatives throughout the World

NOTED AND QUOTED

(*Continued from page* 18)

bosses, to say, "This is a man who performs; therefore, this is a man who is valuable."

"How to Make a Hit with the Boss"
Henry B. du Pont
Address at the
La Salle College Commencement

Nuclear Needs in Florida

Florida is one of the three states of the country having the highest fuel cost; therefore, it stands to benefit most from such a development [nuclear energy].

Joseph Weil
"Atomic Energy—Its Role
in Florida's Future"

MARGINAL NOTES

Through the Looking Glass

The Properties of Glass, Second Edition. George W. Morey. A.C.S. Monograph No. 124, Reinhold Publishing Corp., New York (1954), 591 pp. $16.50.

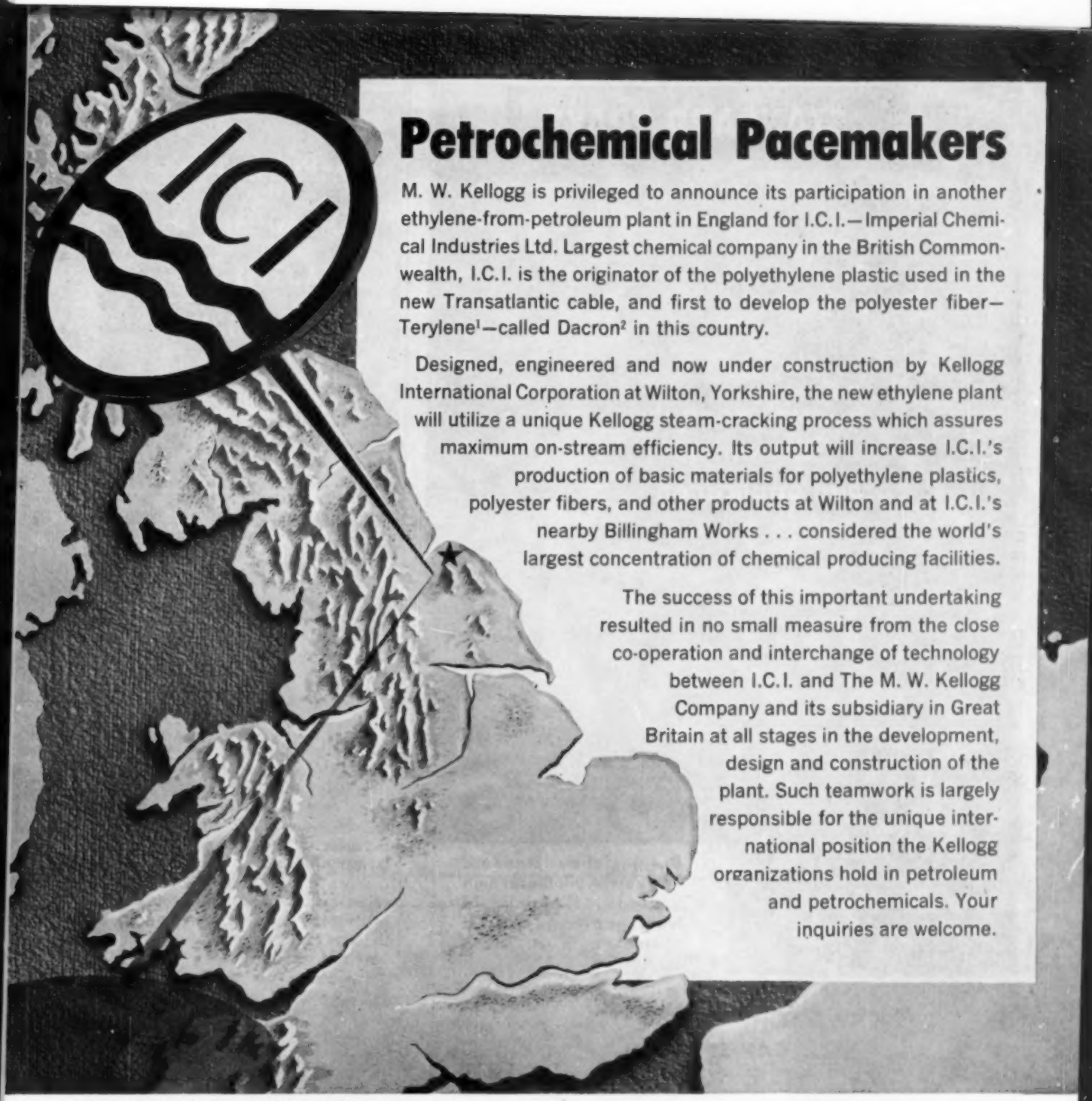
Reviewed by A. W. Davison, Consulting Engineer, Newark, Ohio.

In presenting the second edition of his excellent treatise on the properties of glass, Dr. Morey has rendered a notable service to all technologists and engineers concerned with research operations, production, and utilization of glass, and objects made from glass. In scope the volume covers the fields of composition, methods of testing, and properties of glasses.

The more than sixteen years that have elapsed since the appearance of the first edition have been significant ones in the history of the glass industry. Unusual developments have occurred in both academic and industrial research. Through these efforts a large amount of new information on glass properties has been published. The present edition includes "all new measurements on glasses of known composition, with special emphasis on systematic studies. In addition, much new material has been included on complex and commercial glasses, on theoretical speculations, as well as new sections on the effect of heat treatment on the properties of glass, and of absorbed radiation."

Dr. Morey's chapter on "The History and Definition of Glass" is a notable historical account of the background of glass technology. Unfortunately, however, no mention is made of that im-

(*Continued on page* 22)



Petrochemical Pacemakers

M. W. Kellogg is privileged to announce its participation in another ethylene-from-petroleum plant in England for I.C.I.—Imperial Chemical Industries Ltd. Largest chemical company in the British Commonwealth, I.C.I. is the originator of the polyethylene plastic used in the new Transatlantic cable, and first to develop the polyester fiber—Terylene[1]—called Dacron[2] in this country.

Designed, engineered and now under construction by Kellogg International Corporation at Wilton, Yorkshire, the new ethylene plant will utilize a unique Kellogg steam-cracking process which assures maximum on-stream efficiency. Its output will increase I.C.I.'s production of basic materials for polyethylene plastics, polyester fibers, and other products at Wilton and at I.C.I.'s nearby Billingham Works . . . considered the world's largest concentration of chemical producing facilities.

The success of this important undertaking resulted in no small measure from the close co-operation and interchange of technology between I.C.I. and The M. W. Kellogg Company and its subsidiary in Great Britain at all stages in the development, design and construction of the plant. Such teamwork is largely responsible for the unique international position the Kellogg organizations hold in petroleum and petrochemicals. Your inquiries are welcome.

[1] Registered Trademark of Imperial Chemical Industries Ltd.

[2] Registered Trademark of E. I. DuPont de Nemours & Co., Inc.

M.W. Kellogg

ENGINEERING FOR TOMORROW

THE M. W. KELLOGG COMPANY, NEW YORK 7, N. Y.

The Canadian Kellogg Company, Limited, Toronto • Kellogg International Corporation, London.

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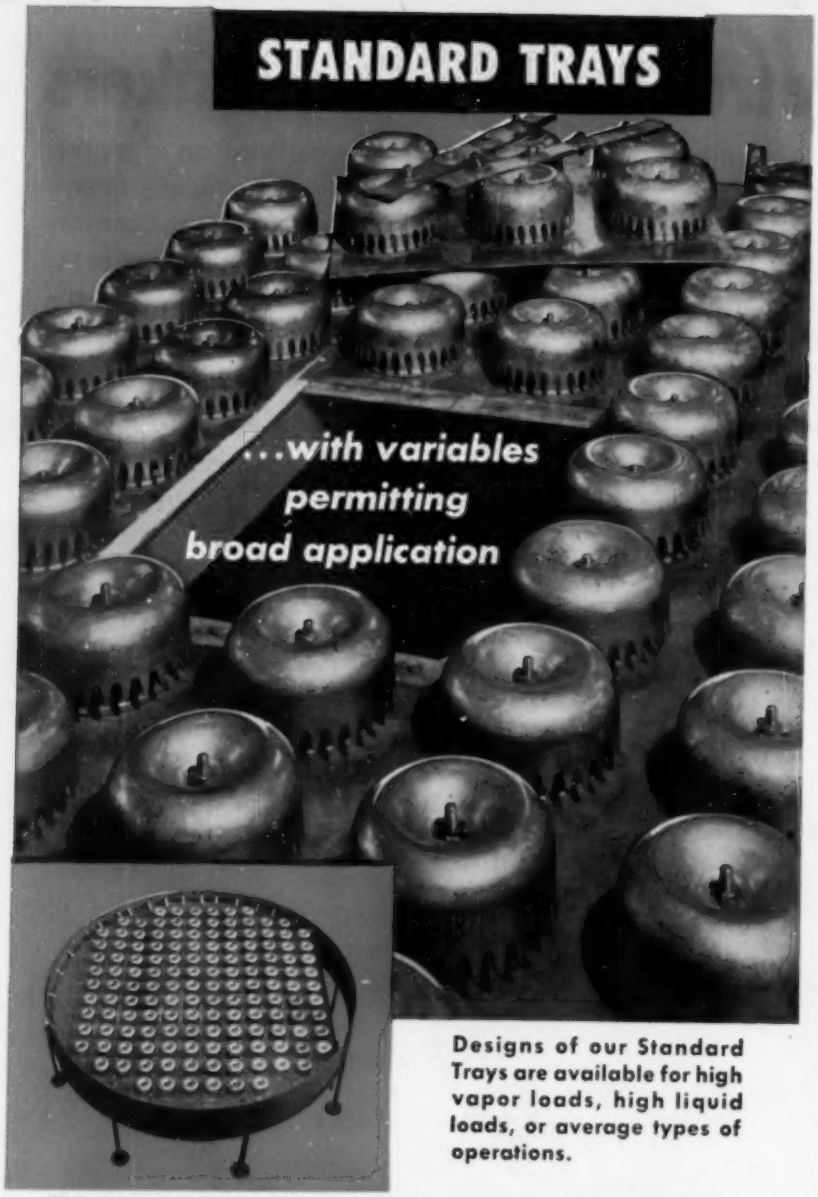


Designs of our Standard Trays are available for high vapor loads, high liquid loads, or average types of operations.

Flexibility in design comes from these three principal variables:

1 CAP SIZE

2 CAP SPACING

3 SKIRT CLEARANCE

These trays are self-supporting on column tray rings up to 10 foot column diameters, thus eliminating the need for extra perlins or beams on such sizes. They are available in all diameters used in practice and in all commercial metals.

Engineering and Manufacturing
Process Equipment of Our Design to Solve Your Problem

Inquiries should include process information in order that we may offer the proper tray design for each process. With other types of trays also available, we can offer an exceptionally wide selection. You will get the best tray for your requirements.

BADGER MANUFACTURING COMPANY

230 BENT STREET, CAMBRIDGE 41, MASS., 60 EAST 42nd STREET, NEW YORK 17, N. Y.

MARGINAL NOTES

(*Continued from page 20*)

portant development achieved by the industry during the past twenty years in the production of fibrous glass materials.

The chapters on Devitrification, Composition, Chemical Durability, and The Constitution of Glass are exceptionally well done. The material therein contained is a valuable source of information to the scientist, to the engineer, or to the layman whose interest in glass is casual rather than intimate.

But the meat of the book is in chapters five to nineteen inclusive (pages 101 to 547). Here the author treats with complete authority such important physical properties as viscosity, annealing, surface tension, heat capacity, density, thermal conductivity, coefficient of expansion, strength, elastic properties, thermal endurance, hardness, electrical conductivity, optical and dielectric and magnetic properties of the glasses.

Organic Coating Technology, Vol. 1, Oils, Resins, Varnishes and Polymers. Henry Fleming Payne. John Wiley & Sons, New York (1954), 657 pages, $10.00.

Reviewed by J. S. Long, University of Louisville, Louisville, Kentucky.

As expected by those who know Henry Payne, his book is thorough and stimulating and represents well the state of this branch of science in 1954. It will be helpful to engineers, to paint technologists, to chemists, and to men in many industries.

When it takes two volumes of 650 pages each to represent Payne's ideas in compact form, one gets an idea of the state of development of paint knowledge and theory.

Payne's concept on hydroperoxides (p. 26) is a bit dogmatic. He does not in my judgment give enough emphasis to odorless mineral spirits. He has an excellent section on silicones and heat-resistant paints, but the 36 pages devoted to this are somewhat out of proportion to 10 pages devoted to the vitally important epoxies. Also, polyvinyl acetate gets only a couple of incidental lines, whereas this class is important. However, this can be understood for PVA has assumed its importance more recently. This is an illustration of the fact that almost any book written on science is slightly wrong in its emphasis by the time it appears in published form.

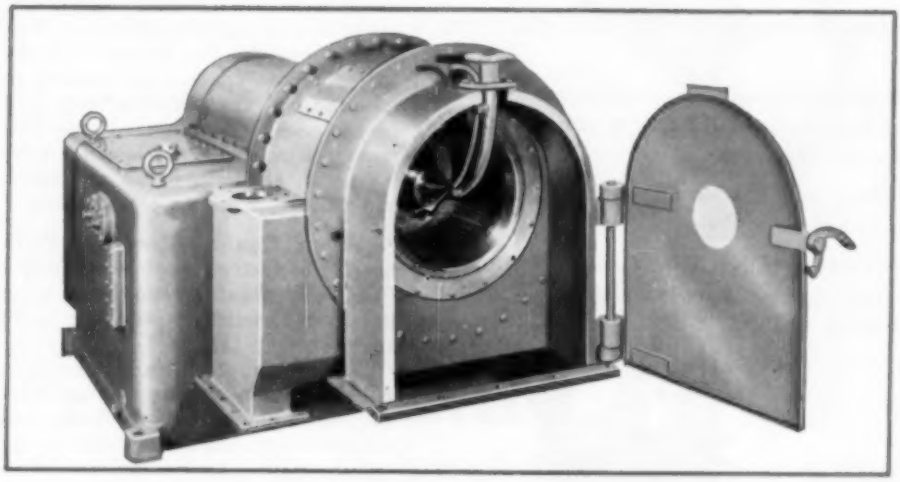
Payne gives an interesting summary and bibliography at the end of each chapter. This is good.

Instead of presenting from the empirical or factual point of view, the

(*Continued on page 24*)

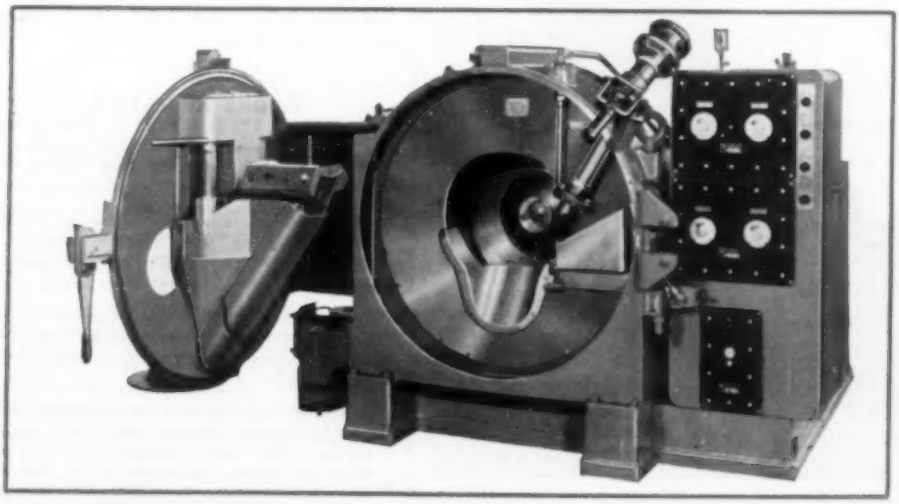
GET EFFICIENT CENTRIFUGATION OF FILTERABLE SLURRIES WITH BAKER PERKINS CENTRIFUGALS

These two types of Baker Perkins centrifugals will handle practically any kind of filterable slurry. The Type S Continuous and the Type HS Universal Filtering Centrifugal are available in a wide range of capacities, and all units are low in power requirement and operating cost. A B-P sales engineer is a specialist in centrifugation so why not let him help you with your product problems. Write, or call us today.



B-P TYPE S CONTINUOUS CENTRIFUGAL

This machine is designed for slurries of relatively coarse crystalline, granular, or fibrous solids.



B-P TYPE HS UNIVERSAL FILTERING CENTRIFUGAL

This is designed for slurries of solids finer than 100 mesh, with high or low viscosity liquid phase.

BAKER PERKINS INC. 304

CHEMICAL MACHINERY DIVISION • SAGINAW, MICHIGAN

HOW YOU BENEFIT WITH GIRDLER CATALYSTS

Cuts consumption of nickel 50% with

GIRDLER G-12 CATALYST

at Celanese Plant, Bishop, Texas

APPLICATION: Hydrogenation, employing a nickel type catalyst.

TECHNICAL SERVICE: Girdler engineers suggested installation of a supplementary G-12 catalyst case for further purification of the hydrogen.

RESULTS: Has cut consumption of expensive hydrogenation catalyst in half.

Technical personnel of the Girdler Catalyst Department will gladly assist you in your catalyst problems. Write for a copy of Bulletin G 260.

The GIRDLER Company

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GAS PROCESSES DIVISION: New York, San Francisco
VOTATOR DIVISION: New York • Atlanta • Chicago • San Francisco
In Canada: Girdler Corporation of Canada Limited, Toronto

MARGINAL NOTES

(*Continued from page 22*)

author shows the reader how to think fundamentally and to consider paint vehicle facts in terms of underlying molecular theory and fundamentals. This is particularly valuable. He relates properties to composition. He links together by systematic chemistry the types and terms that appear in the paint man's vocabulary.

The Application of Operations Research to Industry. Operations Research Office, Johns Hopkins University, operating under contract with the Department of the Army. (1955) 62 pages, $1.75. (Order from U. S. Department of Commerce, Washington 25, D. C.)

Techniques of scientific analysis, borrowed from military tactical operations, are applied to industrial planning. This volume describes the functions of the operations analyst and his relations to the executive, the analytical tools used in operations research, and case histories. It includes a checklist for solving action problems, useful references, and a list of interested organizations.

"Speaking Can Be Easy For Engineers," booklet of Engineers' Council For Professional Development, is in its second printing, is available to all engineers.

Coming from three years' work of an ASEE committee, the booklet is a valuable document for all engineers, has received such enthusiastic response the second printing was ordered.

Cost of the manual is 50c and it is available from ECPD, 29 West 39th Street, New York.

Books Received

The Science Book of Wonder Drugs. Donald G. Cooley. Franklin Watts, Inc., New York, N. Y. (1954), 247 pages, $2.95.

Organic Syntheses. Collective Volume III. Edited by E. C. Horning. John Wiley & Sons, Inc., New York, N. Y. (1955), v-x+890 pages, $15.00.

Molecular Vibrations. E. Bright Wilson, Jr., J. C. Decius, and Paul C. Cross. McGraw-Hill Book Company, New York, N. Y. vii-xi (1955), 388 pages, $8.50.

Abstracts of the Literature on Semiconducting and Luminescent Materials and Their Applications, 1953 issue. Compiled by Battelle Memorial Institute, Sponsored by The Electrochemical Society, Inc. John Wiley & Sons, Inc., New York, N. Y. (1955), iii-x+169 pages, $5.00.

Dielectrics and Waves. Arthur R. von Hippel. John Wiley & Sons, Inc., New York, N. Y. (1954), vii-xii+284 pages, $16.00.

Michael Tswett's First Paper on Chromatography. Gerhard Hesse and Herbert Weil. M. Woelm-Eschwege (1954), 35 pages, $2.00.

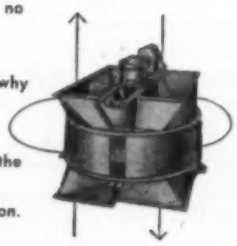
reduce slag

stay on stream at top capacity months longer with the Ljungstrom® Air Preheater

HOW FAST IS "WRITE OFF"?

By cutting turnaround time alone, the Ljungstrom means major savings for you. When you take the other Ljungstrom advantages into account—up to 20% fuel saving . . . more economical furnace design, with no need for convection surfaces . . . burns many fuels you used to throw away . . . consistently higher through-put . . . higher product quality—you can see why a Ljungstrom is paid out in just a few months.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits attainable in fuel burning equipment—call or write The Air Preheater Corporation.



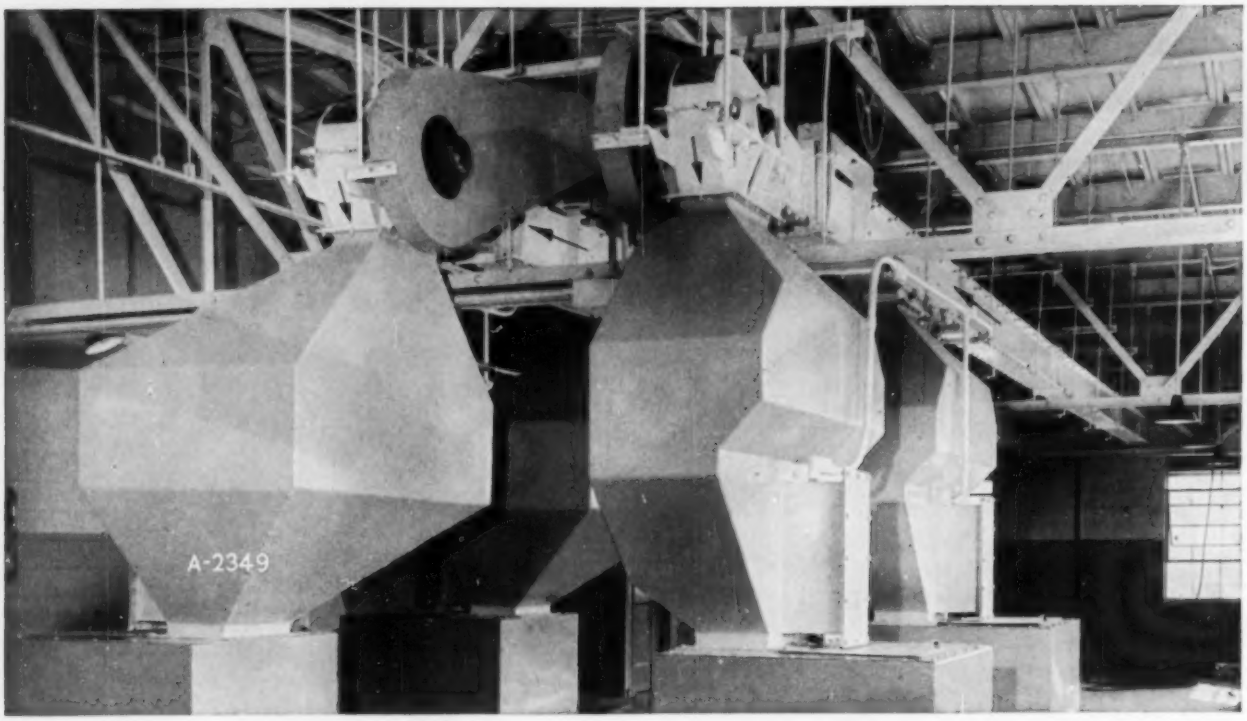
Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

Slag—primary cause of reduced capacity—can be substantially reduced by the Ljungstrom Air Preheater.

That's because preheated air mixes more thoroughly with fuel. The result is better combustion . . . and less slag-forming material present in the furnace. Oil tubes stay cleaner . . . stills stay on stream at top capacity for months longer. As an example, one pipe still in an eastern refinery dropped from 16,000 barrels a day to 12,000 because of slag. Now, with a Ljungstrom and modern high-temperature burners, the still operates continuously at 18,000/20,000 barrels.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.



Sealed Conveying Pays Off Here

Push-Button S-A REDLER SYSTEM Moves Chemicals In Dust-Free, Moisture-Protected Flow

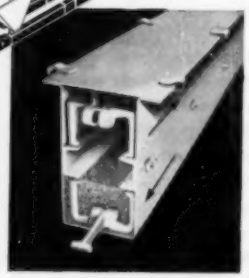
"Move alum and lime for water treatment to an overhead storage system — do it economically without dusting — and protect the easily hydrated materials from moisture." This handling problem at the Radford Arsenal, Radford, Virginia, was completely solved with the installation of an S-A Redler Conveyor-Elevator system.

Casings of these compact conveyors are completely sealed — even the connections between units are gasketed. Dust can't get out — moisture can't get in.

REDLERS bring other important advantages vital to automatic handling. They are self-feeding, will not jam when choke-fed and are exceptionally compact. They are self-cleaning, insuring product purity on every run. Power requirements are low and REDLERS, because of their minimum weight, cut support requirements. All this adds up to push-button conveying at low cost per ton for Radford Arsenal.

If you have the problem of moving anything from coal to cornstarch — without dust or product contamination — REDLERS are an economical answer. For full details, write for Catalog No. 140.

AT RADFORD ARSENAL, REDLER system is push-button controlled. Pressing a single button opens motor-operated gates under feed hoppers and starts REDLER Conveyor-Elevators. Chemicals are carried 50-ft. vertically and 50-ft. horizontally to surge bins. Lime moves at 2-tons per hour, alum at 3-tons per hour. S-A Tellevel control closes feed gates when bins are full. Conveyors run until thoroughly cleaned out. Then button re-sets.



Cross-section through standard REDLER unit. Skeleton flights attached to chain links move material in a solid column, minimizing dust formation and degradation.

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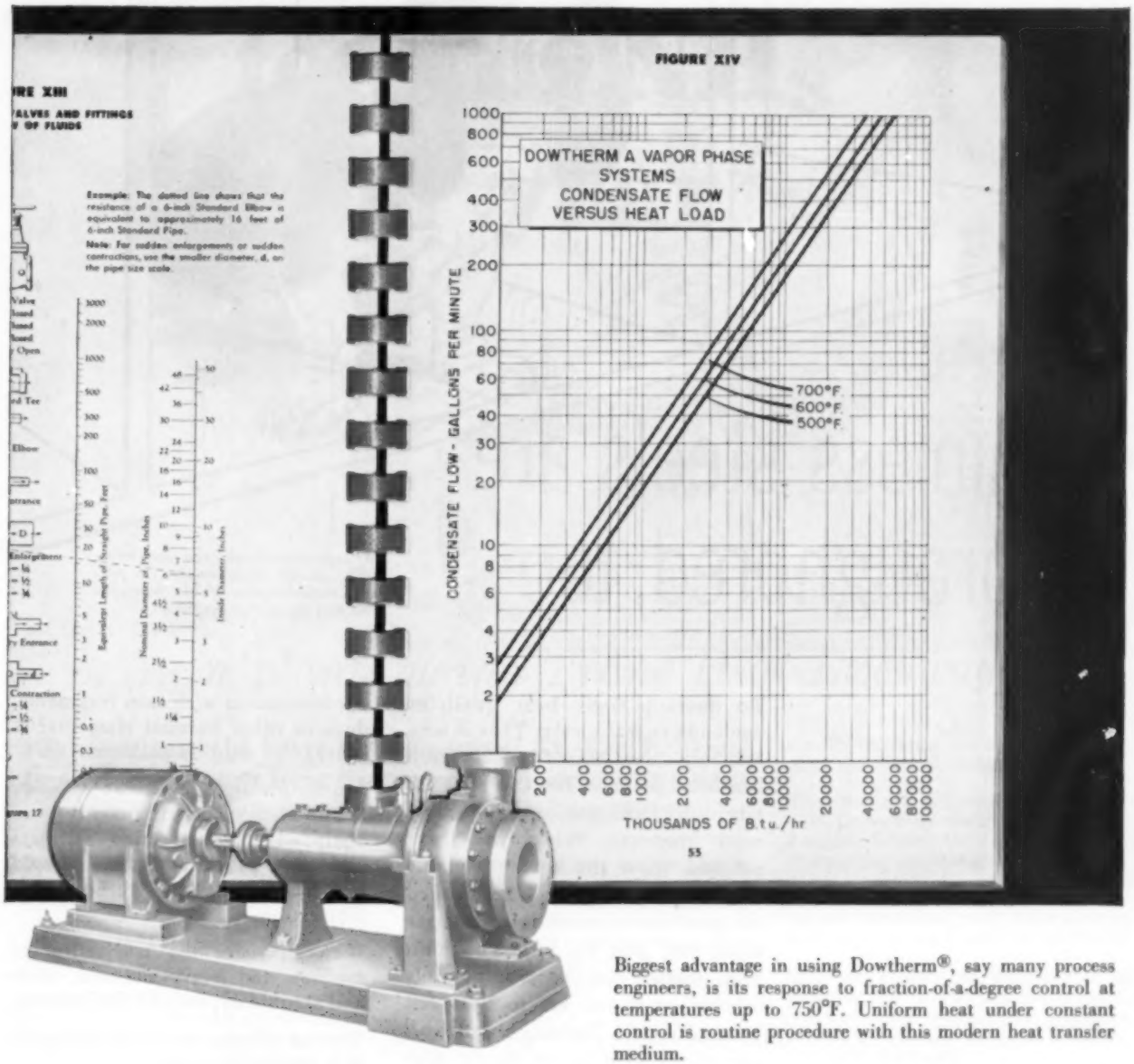

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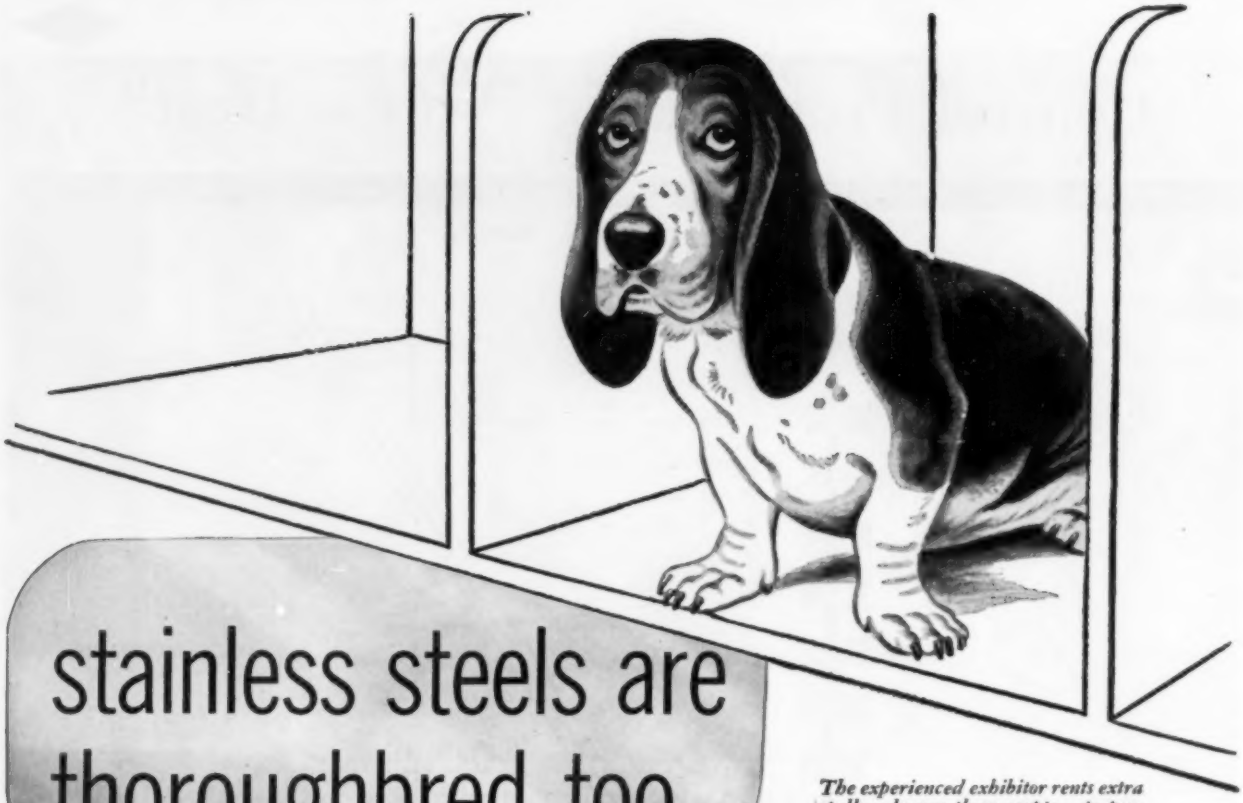

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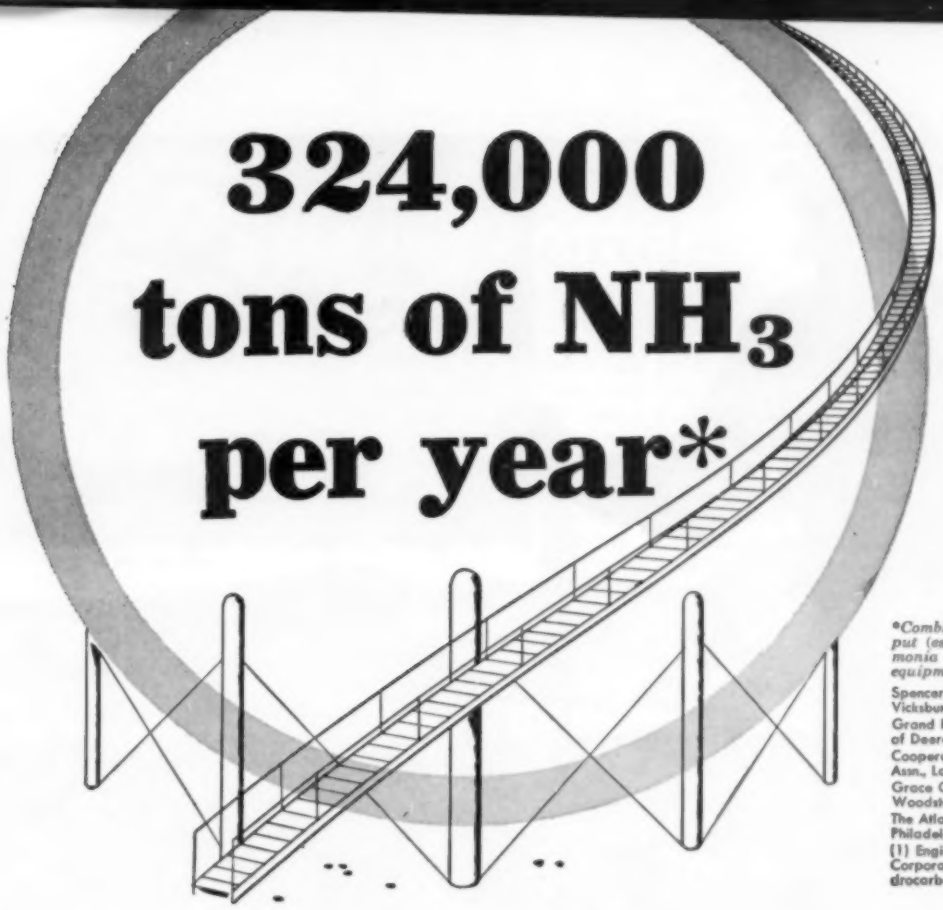

*Combined yearly capacity output (est.) of following five ammonia plants using TRANE equipment:

Spencer Chemical Company (1) Vicksburg, Miss.
Grand River Chemical Division (1) of Deere & Company, Pryor, Okla.
Cooperative Farm Chemicals (1) Assn., Lawrence, Kan.
Grace Chemical Company (1) Woodstock, Tenn.
The Atlantic Refining Company (2) Philadelphia, Pa.
(1) Engineered by Foster Wheeler Corporation. (2) Engineered by Hydrocarbon Research, Inc.

. . . *in plants using Trane Heat Exchangers*

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THE FIVE MODERN AMMONIA PLANTS listed above—estimated total NH3 capacity 324,000 tons per year!—are but a few of the many modern plants using TRANE Brazed Aluminum Heat Exchangers for low temperature applications.

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LOWER INITIAL COSTS—lower installation costs, too—are among the reasons for the steadily increasing use of TRANE Brazed Aluminum Heat Exchangers.

These compact, light-weight units pack up to 450 square feet of heat transfer surface into a single cubic foot. Units are now available for operating pressures *up to 600 psig!*

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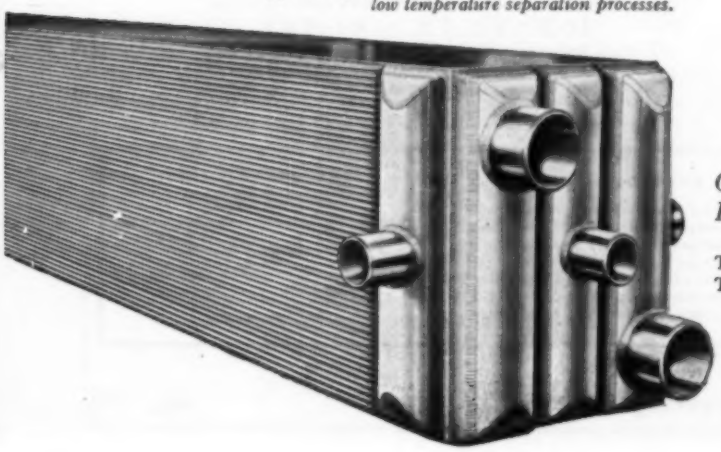
TRANE *Brazed Aluminum Heat Exchanger of the type used for air separation, ammonia, and other low temperature separation processes.*



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NEW STRENGTH FOR NEW ENGLAND

...as GIRDLER designs and builds Anhydrous Ammonia Plant for Northern Chemical Industries, Inc.

NEW ENGLAND agriculture and industry will soon have its first local source of anhydrous ammonia, in the new Searsport, Maine, plant of Northern Chemical Industries, Inc., an affiliate of The Summers Fertilizer Company, Inc. The new plant is being engineered by Girdler to use *low-grade oil* as a raw material . . . the first such plant in the United States to do so.

The Girdler-built plant will produce 125 tons per day of anhydrous ammonia, a portion of which will be used to produce nitric acid and nitrogen solutions. The anhydrous ammonia and nitrogen solutions will be used for direct soil application and in mixed fertilizers. A part of the anhydrous ammonia will be marketed for industrial use.

Girdler has broad experience in designing and building plants to produce ammonia, ammonium nitrate, and other agricultural chemicals . . . and in construction of high-temperature, high-pressure process plants. For more information on this and the many other types of plants listed below call the nearest Girdler office today.

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Vinyl Foam Fusing	Wood Bonding
Plastisol Fusing	

CEP trends / HYDROGEN PEROXIDE

Hydrogen peroxide, long familiar as a chemical specialty and textile bleaching commodity, appears to be rapidly coming into the status of a major chemical raw material.

Chemical engineers have long had their eye on peroxide as a possible highly valuable agent to use in a number of newer chemical processes but up until recently it has been too costly for really large scale chemical use.

In the past most of the peroxide has been made electrolytically by converting sulfates to persulfates, which release hydrogen peroxide when treated with sulfuric acid.

In the last year or so several new chemical processes for making peroxide have been put to industrial use, and though the makers are reluctant to discuss economics, it is believed that costs under the new methods might be as low as one half to two thirds the cost of electrolytic peroxide.

Three in Race

Three major chemical firms, Allied Chemical & Dye, Shell Chemical and Du Pont have already entered the field of chemical production of peroxide with new chemical uses in mind.

Allied's process, for which a plant is being built, will involve "chemical oxidation using raw materials mainly available from the firm's own plants." Shell is believed in the trade to be using the oxidation of isopropylene. The new Du Pont plant is believed to be using anthraquinone as a starting point.

Shell's new venture is especially interesting because it provides a concrete example of how the peroxide can be used to make other chemicals. Shell has long been interested in the production of synthetic glycerine, long used in alkyd resins and more lately for plastics. As production of natural glycerine from the soap industry declined, because of the huge growth in the use of synthetic detergents, demand for glycerine increased. Shell in its new plant at Norco, La. has a three pronged process. It will produce 30 million pounds yearly of hydrogen peroxide in one plant. In another plant it will make acrolein—another chemical with an apparently glamorous future—and will then react this with the peroxide to produce its glycerine.

Allied has revealed no plans as yet for using its own hydrogen peroxide but it is believed the company has its eye on a number of interesting new markets. Meanwhile about 70% of all textiles use the material for bleaching. Du Pont also is understood to be looking into a number of chemical uses. One is a method developed by Du Pont for the epoxidation of fats and oils to convert them into more useful products. This is part of the chemical search for new ways to utilize the surplus of natural fats and oils, again the result of the use of synthetics by the far flung soap industry.

Buffalo Electro-Chemical Co., long a producer of peroxide by the electrolytic method, is also understood to be working on new processes.

The basis for all of the new peroxide processes is to take an oxidizable "carrier," or organic hydroxyl compound such as anthraquinone, oxidize it to a "per" state, decompose it to a ketone, with hydrogen peroxide being evolved. The ketone is then hydrogenated back to the hydroxyl state, and is ready for recycling. This process not only requires less expensive plants but consumes much less power. Origin of process goes back to Germany, where large quantities of peroxide were made during the war for the V-2 rocket and other programs.

Cheaper peroxide is expected to open the way for the use of a number of interesting processes for treating hydrocarbons from petroleum, including the making of petrochemicals, which have heretofore been shelved because of the high cost of the peroxide. The Shell method of making glycerine is but one example. Some chemical engineers go so far as to say that cheaper peroxide will mark a major milestone in the chemical industry.

Outside of its older uses for bleaching textiles and wood pulp, and its new and upcoming chemical uses, hydrogen peroxide has interesting and important possibilities as a fuel for rockets, jet planes and submarines. It is already used to propel torpedoes. In submarines it has already been used by the Germans to power several successful WW2 craft.

Peroxide vs. Atomics

As to military markets, the U. S. Navy is believed to have conducted a good deal of research on the use of peroxide in submarines. There is a school of thought that believes peroxide driven submarines, with their longer cruising ranges than conventional types might have some important advantages over the atomic submarines, chiefly because they would be much cheaper and so many more could be built for the same money and effort. Atomic engines are extremely heavy and costly and require very heavy shielding, which means in turn a bigger vessel and a heavier hull. The British have for some time been working on peroxide driven submarines and have published some information on this subject.

None of the American firms now building plants to produce peroxide by the new techniques apparently have an eye on military markets because there are none known to be definitely in sight in this country. There appear to be enough possibilities in new chemical uses to spur its commercial development.

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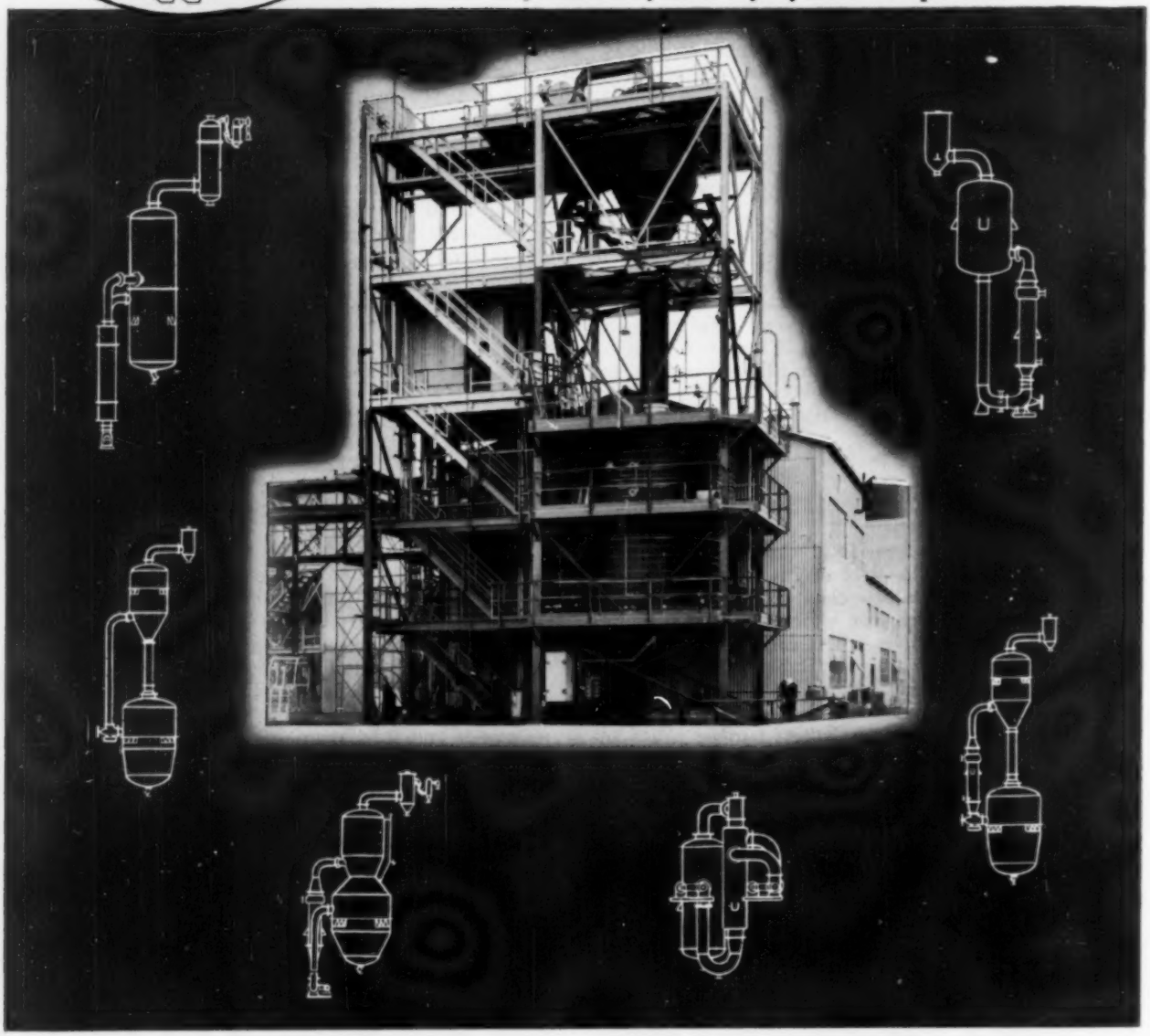

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CEP what's in this issue...

you may be interested in—

TONNAGE PEROXIDE - (p. 31) - wouldn't be interesting if our chemical industry were using the traditional process . . . New techniques, based on German technology, setting stage for a marketing race, with a big name slate . . .

WHAT'S THE FUTURE for chem engineering education? - (p. 299) - You MIGHT be surprised, the way some of our leaders - and some of those in Europe - are talking these days . . . Read C.E.P.'s first-hand report on the Houston & London meetings.

MAKING ROCKET PROPELLANTS - (p. 302) - is getting to be a sizeable business . . . Here is what you need to know about how the manufacturing techniques differ from what has been tradition - evidently, if you'll pardon it - from use of some chemical engineering techniques . . .

CONTINUOUS REACTORS - (p. 303) - are still difficult to design in spite of their wide use throughout the chemical and petrochemical industries. In this brief article, author Sherwood proposes what may be an important solution to a basic problem . . .

EUROPEAN CHLORINE CELL designs - (p. 305) - are well to keep an eye on, judging from the trend - in the last five years we have increased our production by 10% using mercury cells of original German design. Platzer of Monsanto reviews the entire picture . . .

YOU CAN LEARN A LOT about evaporators - (p. 313) - particularly if you are concentrating radioactive wastes and can't have any entrainment. That's what happened at Brookhaven, as told in an article covering several types . . .

ZIRCONIUM MANUFACTURING PROBLEMS - (p. 320) - have required special solutions which may be broadly applicable to the producing in the future of other tightly-locked metals . . .

MOVING BEDS of solids - (p. 326) - are widely employed throughout the process industries. Typical example is the fluidized bed. In this attractive paper, author Berg reviews what one needs to consider for design.

MARKET FOR HIGH ENERGY MATERIALS - (p. 335) - is best predicted from how they're used, in what forms. One of the latter is a commercial gas generator . . .

A MAN WHO WILL HOLD STILL while he is "fed" executive training is not too likely to be choice grade top executive potential - (p. 339)

PHENOL FROM CUMENE - (p. 35) - may sound like a lot of chemistry, but the real basis for the new Hercules plant (Gibbstown, N. J.) is the acetone market . . .

PLANT CORROSION TEST DATA - (p. 36) - is usually good reading, particularly when it concerns a brand new stainless steel - Nionel . . .

ANNUAL INSTITUTE ELECTION will be coming up this fall. Under new rules, data concerning candidates is published in this issue. You'll find name, picture, office involved, and a brief biographic sketch of each person selected by the nominating committee, plus those nominees-by-petition on hand when going to press . . .

RELAX - AT LAKE PLACID! - (p. 44) - The first of our previews of this meeting features this luxurious resort as a place to come to this September - after summer has pretty well frayed your managerial temperament . . .

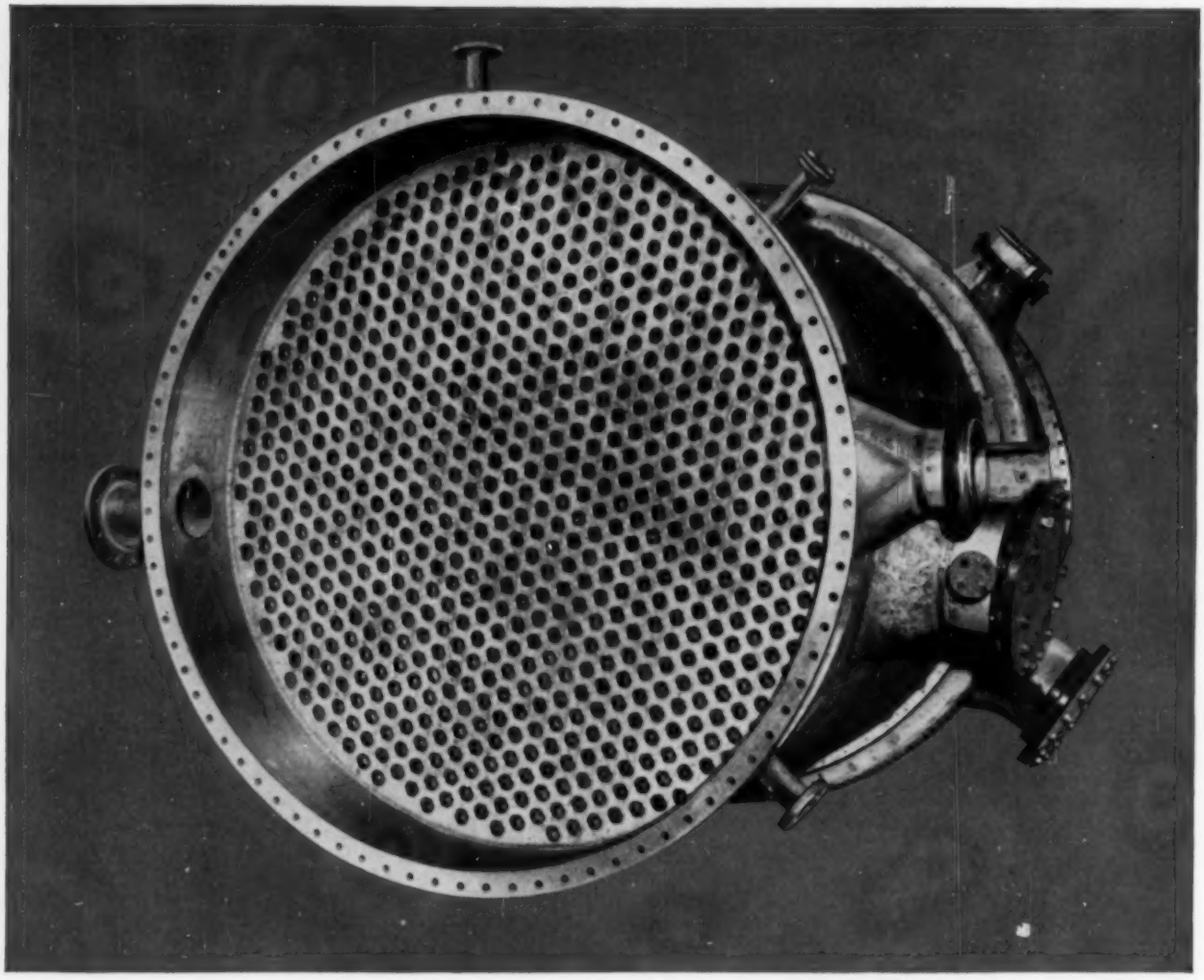
NEW DATA SERVICE! - (cardboard insert) - Don't miss this newly redesigned feature, with a special section reporting on significant developments in commercially available processing equipment . . .

WHO TAKES PLANT TRIPS at Institute meetings? - (p. 70) - At our request, the American Oil Company photographed several groups going through their Texas City refinery during the Houston A.I.Ch.E. meeting . . .

WHO ATTENDS? - (p. 72) - A comparative tabulation of Louisville and Houston meetings shows ¾ of the attendees fall into 3 classes . . .

EXCLUSIVE! C.E.P. INTERVIEW WITH MAN WHO SPEARHEADED DRIVE BACKED BY INDUSTRIAL AND EDUCATIONAL LEADERS TO GET PROBLEM OF LOCATING ENGINEERING CENTER RESOLVED WITHOUT PRESSURE - (p. 85)

- J. B. M.



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CEP

opinion and comment

LOOKING AHEAD

At this point in midyear, it is possible to pass along to you a preview of C.E.P.'s editorial plans for the remainder of the year.

With this, the *July* issue, we are departing a bit from our recent pattern of Data Service, by including illustrated announcements of what appear to be significant developments in commercially available products.

The *August* issue will concentrate on process control, with several articles directed at the interests of many chemical engineers in this subject. By this, we mean material which relates to understanding, and experience, relating to the use of control systems and devices to attain certain desired processing objectives. August will also include the detailed advance program for the Lake Placid meeting. With this, and previews of later meetings, we hope to be doing more reviewing of papers—in advance of the meetings, to encourage broader understanding of the objectives behind program planning.

September will feature maintenance and management . . . the former theme being based on a recorded round table session held with men responsible for maintenance in a number of the large Southwestern petrochemical and refining plants, who discussed what is going on in these tremendous "proving grounds" for equipment and materials. As to management, we expect to have selected Lake Placid papers.

October will be our nuclear engineering issue, carrying a full slate of the more interpretive papers from among those being sponsored by the A.I.Ch.E. at the E.J.C. Nuclear Congress. It is expected that these papers will carry a considerable amount of new information. We will also have a complete directory to the Atomic Exposition, listing exhibits information. October will also carry the final program details for the Detroit Annual Meeting.

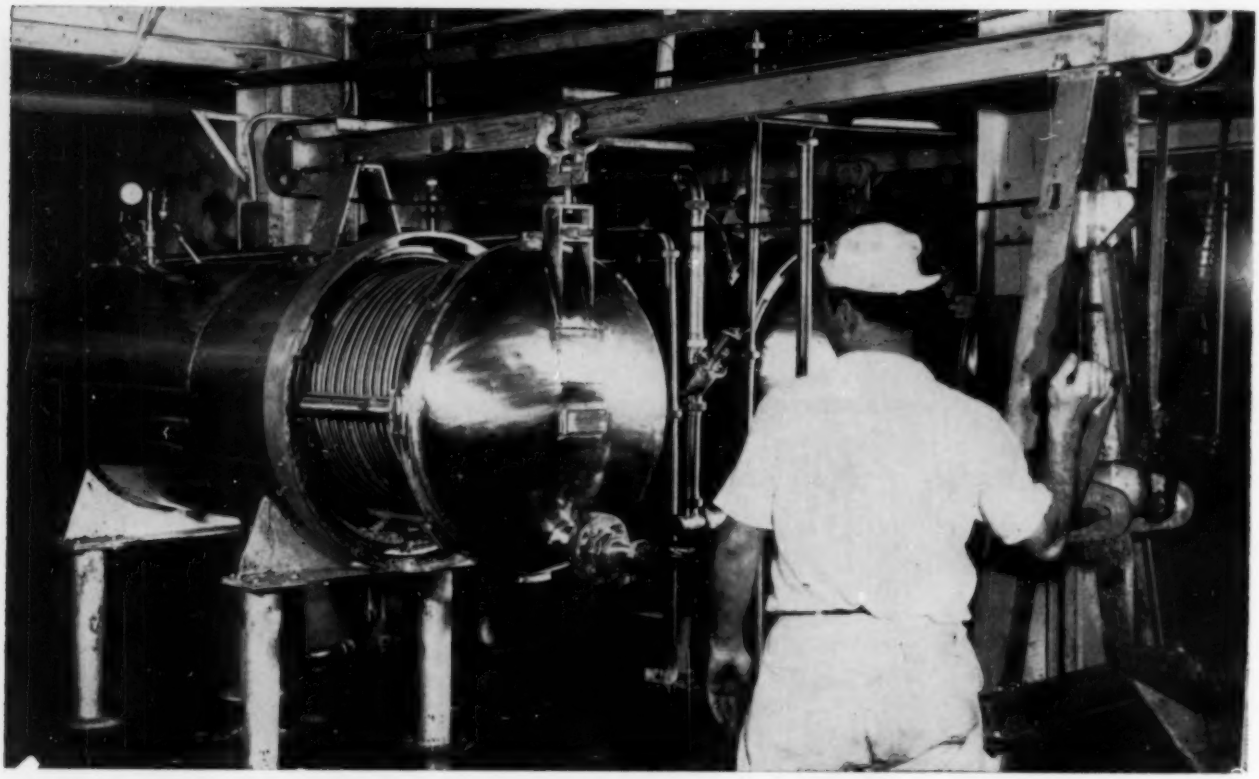
The *November* issue will carry our traditional directory to the Chemical Exposition, with information both for the reader planning to attend the show, as well as the stay-at-home. The latter will have easy access to the data folders to be distributed at the exposition booths, through use of our Data Service.

December will round out the year's editorial program with an issue devoted to cost estimation. Keynote will be another recorded conference with leading cost estimation engineers from major southwest petrochemical and refining plants. There will be a number of papers on this subject.

It is not possible to mention at this time the host of special features which we have under way, or will have from time to time. These necessarily vary considerably in timing for publication.

I would like to at this time thank those who are being so helpful in preparing material for the magazine, and who are giving us such good counsel. In this latter connection recognition should be given the fine job being done by the C.E.P. Advisory Board, which by every standard is an effective working organization.

J.B.M.



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CHEMICAL ENGINEERING EDUCATION

Educators, businessmen, are taking long look at the engineer and his education. Chemical engineering is receiving one of the closest scrutinies, with contemplated sweeping changes in basic concept. Two recent meetings—in London, at Houston—highlight growing ferment, show startling contrasts. *CEP* obtained from two leading educators * the following comments on sessions.

Nearly everyone agrees the basic characteristic of engineering is "design." But there is technically correct design (pure and engineering science) and economically correct design (social science, human relations).

Essence of newest U. S. concept is to teach the "science" of chemical engineering rather than the more procedural "art." Emphasis on theory not technology.

Current European aim—greater professional recognition, acceptance of "science" behind presently taught and practiced "art." One *CEP* advisor sees possibility Europeans, when they accept the "science," might jump over America, adopt more fundamental approach to a degree we might not reach in near future.

Strong Houston emphasis on fundamentals shows current tendency for all engineering to blend in practice, boundaries fading, basic science underlying all engineering now coming to fore.

part 1 | AMERICAN MEETING

At the recent Houston A.I.Ch.E. national meeting *CEP* took a special look at the symposium on chemical engineering curriculum, found basic agreement among four speakers on need for more rounded program, greater flexibility of graduates, teaching of basic science rather than technology, necessity for revising current educational pattern.

Challenging speaker was R. R. White, University of Michigan. "Real problem," said White, "is to take Joe Doaks, average I.Q., and do a decent job on him as far as basic education is concerned in about 4 years. We turn our backs on the problem if we start restricting engineering enrollment to the specially gifted or if we solve the problem by simply allowing more time. We've got to keep fighting the basic problem of a 4-year job with a regular fellow."

But the problem, White emphasized, is not simply one of engineering education, or even education in general, it is a national, possibly world-wide, problem covering the whole field of knowledge in relation to society. "Things have been happening in industry in the last 15 years, combined with World War 2, that are keeping things going at such a high rate of change that we who are in the middle have great difficulty getting perspective. It poses tremendous problems for education. If we were to list all the suggestions to be added to the engineering curriculum you would be appalled at their diversity. . . . We have to train a gentleman, a scholar, and a technological wizard."

On top of this, White points out, ". . . we're finding it increasingly difficult to describe what chemical engineering is. Classical boundaries disappearing . . . hard to tell difference between chemical engineer, mechanical engineer, and physical chemist when you see them working in industry."

To make it even more difficult we have too much to teach. The field has grown so much that a "splintering" process has set in leading to myriad special fields—the universal problem of over-specialization and what does it do to education. We have protective coating engineers, nuclear engineers, instrumentation engineers, systems analysts, etc. Even unit operations and processes are so numerous now we can't count them.

Taken with one of the keynotes of the whole symposium, the great need for flexibility of both attitude and aptitude in engineers, White felt there was one basic answer—"Train him in science and math but forget about the specific material he's going to have to cover."

Combining all this with problem of 4-year education, White boiled the whole matter down to a few basic principles.

1) In 4-year curriculum put in only that subject matter you would not dare let the student escape without. Minimum of requirements, maximum of flexibility.

2) Don't worry about specific know-how, give student a firm idea of what constitutes a fact, in pure science, engineering science, and the social sciences.

3) Preserve engineering viewpoint, but do it by using engineers as teachers.

To emphasize his points, White showed slides of typical curricula, stressed hodge-podge nature of most. Found some with too much specialization, some with too much pure chemistry, some with "rat's nests" of poorly related courses, almost all with too few electives. He found far too much teaching based on concept of "this is the way it's always been done." Pointed specifically to traditional math courses "lock-stepping" on the old routine that leaves the calculus until too late to be much help in physics or physical chemistry.

Philosophy of White's suggested program is that "a man's professional work is up to him. Only requirement made on him will be that his professional electives shall constitute an experience in some kind of engineering technology."

Essentially, this viewpoint is the basis for Michigan's new "science engineering" program, to be introduced this fall after two year's work. Students will be required to take the absolute, basic essentials for all engineering, elect the basic theoretical courses in the specific branch of their choice. For chemical engineering, the result will be men thoroughly grounded in basic theory and in chemical engineering theory, as well as in the non-technical areas.

"This program affords a science and math base from which a student could take any one of a large number of directions. . . . Engineering is an ideal mechanism for education. We can make gentlemen and scholars, maybe not technological wizards, but flexible and useful citizens."

Underlining White's statements in more general terms, and from industry's point of view, C. E. Reed, General Electric, called for the "well-rounded" engineer.

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* Deans Joseph Elgin, Princeton University, Warren McCabe, Brooklyn Polytechnic Institute.

"If I were asked to describe the ideal engineer from the standpoint of a general manager, my description would be about as follows: At the time of his graduation from college and entry into industry he would be essentially a problem solver . . . would not expect him to be familiar with the technological details of the industry he has chosen to enter . . . thoroughly familiar with the fundamental facts, theory, and techniques and tools of the basic physical sciences, mathematics, chemistry and physics."

Echoing the feeling that permeated the symposium, Reed went on. "The chemical engineer's college career would instill in him intellectual curiosity to acquire a detailed knowledge of the technology which has been developed before his appearance on the scene. His background in basic science would enable him to comprehend this."

In his talk, Reed called for the development of what he called "the skill of balanced judgment" in the student. C. M. Cooper, Du Pont, took this tack as his main point.

"Curricula as we know them," Cooper said, "are planned to give the student access to knowledge, but knowledge, unless it be effectively employed, is useless." Referring to 13 items Du Pont has found it necessary to consider when appraising a man, Cooper pointed out that 12 of the 13 items used are concerned not with securing knowledge but with the effective employment of it. "It was startling to realize that most of the attributes which we seek in our man are picked up by him almost incidentally in his educational and living experiences. . . . The effective man will go much farther with a little knowledge than the ineffective man with all the learning in the land. What we need is both . . . whether our educational system as a whole recognizes our responsibility to develop in students those attributes so essential to the effective application of knowledge."

As a comparison to the theoretical discussions at the symposium, F. M. Tiller's presentation of the new curriculum (1951) under his deanship at Lamar Tech (Beaumont, Texas) showed interesting facets. Teller emphasized his and Lamar's attempt to put into practice one of the theoretical points brought up by White, "One thing we kept attempting to do was to bring those courses which were prerequisites to others down to the earliest level possible in our program . . . in the first two years as much of the fundamental math, physics and chemistry as possible . . . calculus in the first year . . . physics in the first year . . . differential equations in the sophomore year left the junior year to go into thermodynamics and right into unit operations."

But, although there is certainly greater flexibility in Lamar's curriculum than in those in Germany and Sweden (see European Meeting, this issue), the program is still basically composed of required subjects.

Mathematics	12
Physics	10
Mechanics	5
Chemistry	13
Mech. Eng.	4
Elec. Eng.	4
Chem. Eng.	30
Miscellaneous	22
	100%

The higher percentage of miscellaneous, being mostly electives, English, government and physical education, shows a slight tendency toward White's idea of freer education, and a tendency to work on the idea of the better rounded engineer—the basic points raised in the symposium.

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part 2

EUROPE MEETING

The London meeting, in the eyes of Sir Harold Hartley, chairman of the conference and president of The Institute of Chemical Engineers (England), is a milestone as significant for the chemical engineer as the famous first International Chemical Conference at Karlshrue 100 years ago was to the chemist. It has, all present agreed, set in motion forces which will certainly result in chemical engineering achieving a place in Europe equal to the high position it already holds in America.

Sir Harold, and the numerous delegates from all countries, readily admitted that impetus for the conference came from observation of the high position and great productivity of American engineering. Essentially, with one major exception, the result of the conference was a strong endorsement by industrialists of all countries of the American view of chemical engineering.

350 from 13

Professor G. G. Lamb acted as official observer for the A.I.Ch.E. (he is now lecturing in Finland on a Fulbright). Present for the entire 3 days, he reports on the hard-working meeting.

"Sponsored by the Organization for European Economic Cooperation as Project No. 297, the conference was organized by The Institution of Chemical Engineers. Held in Church House, Westminster, the conference used multilingual translations of all talks heard through earphones at each seat.

"About 350 attended the conference, one half being official delegates from 13 countries, the other half mostly English chemical engineers. Fulbrighters Molstad and Amundsen were present from the United States . . . papers had been pre-printed . . . speakers merely emphasized the high spots or amplified their topic . . . left adequate time for discussion, question and comment. Listeners were alert . . . spartan, pew-like seats of Church House . . . much more conducive to alertness than softer seats common in America.

"An excellent spirit of co-operation and friendliness was shown by all members of the conference, and the occasional fairly strong differences of opinion did not arouse antagonism. It was pleasing to note the rather complete acceptance of the American concept of chemical engineering in this conference . . . appears that our accomplishments in America, our literature, and the efforts of Prof. Hougen, and other American chemical engineers who have visited Europe, have been successful."

Function

The function and place in industry of the chemical engineer was a main point of discussion at the conference. With the exception of Germany, all countries present agreed in general on a concept of the chemical engineer close to that held in America, i.e. a member of a profession on an equal footing with the three older engineering professions and having his own specific, separate function to perform.

Still, it became clear that there are many problems still facing the chemical engineer in realizing his full potential in European industry.

Sometimes differences of approach were only a matter of degree, but there is still a definite sense of viewing the chemical engineer in contrasting lights. Two English views demonstrated this well. C. F. Kearton, director, Courtaulds, advanced views essentially the same as those held in America. ". . . a man who can break down into its component parts a manufacturing process in which matter is transformed or chemically changed, provide a specification for each subdivision, and recombine the whole into a flowsheet . . . a fervent belief in the value of the chemical engineering approach and specialized technique . . . preoccupation with design information distinguishes him from the chemist . . . preoccupation with processes divides him from the mechanical engineer."

On the other hand Sir Christopher Hinton, managing director, industrial group, United Kingdom Atomic Energy Authority, presented a view closer to the traditional European approach that still tends to see the chemical engineer as a specialized chemist, or a specialized mechanical engineer. The goal is to train a man as a chemist or engineer and let him become a chemical engineer "on the plant floor." The value of chemical engineering training *per se* is appreciated, but there is a hesitancy about trusting such training without careful additional training on post-graduate level.

Perhaps the peculiar problems of chemical engineering as a profession in Europe were shown best by the speaker from Belgium, N. G. Chorine. Belgian chemical industry, according to Chorine, has developed slowly and hesitantly, due largely to what Chorine calls a lack of the "technological spirit in chemistry." In short, Belgium has a crying need for chemical engineers. At the same time, "the necessity of preparing capable and well-adapted chemical engineers is ignored by a certain portion of Belgian chemical industries and universities."

But Belgium also shows the encouraging signs of development in the right direction. The need is recognized and the work being done is definitely slanted toward the American concept of "unit processes." As Chorine says, "the chemical engineer will be trained so that he no longer 'is sitting between two chairs' as the traditional European view made him."

Generally, then, with certain differences of degree, European industrialists are adopting the view that the chemical engineer has his own unique and necessary place, and that the American concept of "unit processes" is the best approach. But there is one other strong approach—that of Germany.

The Germans have developed over the years a triple-headed system that seems to serve them well—the chemist, chemical technologist, and Verfahrens Ingenieur (process engineer). K. Winnacker, chairman of the board of Farbwerke Hoechst A.G., presented a clear analysis of the German method.

"Chemical engineering," said Winnacker, "is not a definable concept in the German chemical industry . . . we avoid the training of technicians so that they become half engineer and half chemist." In the German view two heads are better than one, i.e. an engineer *per se* and a chemist *per se*, collaborating to do what in America is the chemical engineer's job. Winnacker gave the feeling in a nutshell when he said, "In factories the chemical and engineering problems arising are so numerous and complex that it seems justifiable to have them dealt with by a chemist as well as an engineer." The net result of the German system is a chemist with a familiarity with processes and some engineering, and a "process engineer" trained basically in mechanical engineering and also having a familiarity with processes and chemistry.

But despite Germany's reputation in the field it is definitely the American concept that is holding the day in Europe. As might be expected, the petroleum industry has been the leader in adopting the chemical engineer, while the chemical industry has lagged, tending to still want emphasis on chemistry and chemical technology.

Perhaps the crux of the matter, and best indication of Europe's present thinking, was underlined by Sir Harold in his closing remarks, "It's (chemical engineering) techniques are invading every industry and the hope of satisfying the world's growing demands depends more and more on chemical engineering, call it by what name you will."

Education

Concensus: A great need for much more chemical engineering training, many more schools, and more orientation in the older schools toward the needs of chemical engineering. Reason: Demand for chemical engineers rising in a steep curve far beyond the present supply.

In education the importance of just how chemical engineering is viewed, what is considered its place and function, is immediately apparent. Until it is recognized as a separate discipline, the older schools will be reluctant to institute proper training curricula, educators will be reluctant to organize new schools.

But more than that, the curriculum itself in schools already established is based largely on how the chemical engineer is viewed. At the extremes stand the educational ideas of Germany and Sweden. Present chemical engineering educations in the two countries are given below:

	Germany	Sweden
Mathematics	12	6
Physics	7	4
Mechanics	12	3
Chemistry	13	59
Mech. Eng'g.	24	9
Elec. Eng'g.	2	3
Chem. Eng'g.	15	13
Miscellaneous	15	3
	100%	100%

Obviously, Sweden is training not a chemical engineer but an industrial chemist. Germany, on the other hand, is training a chemically familiar mechanical engineer—their cherished "process engineer."

In general, chemical engineering education in Europe is still rudimentary, with many countries having small, if any, provision for it as a separate technology. In Sweden full professorships were granted only as late as 1947 and 1950, and to date both chairs are vacant.

But the change is coming, even in Sweden and Belgium, two of the less chemical engineering oriented countries. Certainly those at the conference are returning to their countries determined to do something about bringing Europe closer to the American idea of chemical engineering education, with a good chance of something being done in Great Britain and some of the other larger countries.

Basic Research

Along with more and better education, the conference emphasized the necessity for conducting a great deal more basic research in chemical engineering. Again, before this can be done chemical engineering must be recognized as a unique technology, having specific problems of its own, needing its own basic data.

careers

No better indication of the fact that chemical engineering is really a discipline of its own can be found than the problem of lack of basic data outlined by France's Prof. J. Cathala, University of Toulouse.

"Chemical engineering," said Cathala, "must have recourse to methods of investigation which were at one time little in evidence: calculation by graphs, dimensional analysis, statistical analysis . . . some research is necessary to augment the strength of these methods. In fact, for the solution of a particular problem, chemical engineering often finds itself up against an almost total absence of numerical data on the properties of the substance being dealt with. It is indispensible to develop approximate methods for estimating these missing data."

It is clear from this, and many other statements at the conference, that basic research in the older technologies and in chemistry does not suffice for the chemical engineer. Much research is needed, and support must be forthcoming to aid that research.

Certainly no better indication is available of the definite "separateness" of chemical engineering as a technology—a fact the Europeans have for the most part now accepted, and on which they will build the future of chemical engineering in Europe.

PROCESSING COMPOSITE ROCKET PROPELLANTS

Alfred J. Zaehringer | American Rocket Company, Wyandotte, Michigan

In just ten short years processing of modern composite solid rocket propellants has proceeded from a laboratory to a large-scale operation. However, few outside the propellant industry are familiar with the tremendous growth and the processing techniques opened up. This article outlines briefly, within security limitations, the process methods.

A solid rocket propellant is a solid which, by virtue of its self-contained oxidant and reductant, is capable of combustion when activated by an external energy source. Unlike explosives, propellants react or burn at a much slower rate. High explosives detonate at rates in excess of several thousand feet per second; propellants rarely burn at rates higher than 10 in./sec. and most propellants burn at rates of 0.01-1.0 in./sec.

There are two main types of solid rocket propellants in use today. The first is the familiar homogeneous or colloidal class; the single-base (nitrocellulose) and double-base (nitrocellulose-nitroglycerine) propellants are examples of this type. However, the older type of solid propellant is the composite variety. Here the oxidant and reductant appear in distinct phases and may be looked on as mechanical rather than chemical mixtures. Gunpowder is an example of a composite propellant. However, unlike gunpowder, modern composite propellants, which are considered in this paper, are cast rather than compressed.

The advantage of casting propellants is easily seen since propellants may be processed as liquids, cast into the desired shape, and "cured" into a solid form for use. Not only are difficult extrusion techniques avoided, but a small or large grain may be made with equal facility.

Propellant Materials

The common oxidants used currently in composites are the light metal (ammonium, potassium, and sodium) chlorates, nitrates, and perchlorates. They not only offer high oxidation potentials but are low in cost and are readily obtainable. Just about anything that will burn is suitable for a fuel; however, it is more convenient to start with an organic liquid which can not only serve as a fuel but after conversion to a solid will serve as a binder. The reason for this demand is that with most solid, inorganic oxidants at least 50-90% by weight of the oxidant must be used to obtain near stoichiometric (and thus near optimum performance) conditions. The fuel-binder must be strong enough to allow for complex shapes and for good physical properties for the solid propellant at temperatures of about –80° to 180° F. The fuel-binder system may be a simple hot-melt type (a mixture of asphalt and motor oil was an early one) or it may be a modern thermoset type. The present trend is now toward the use of thermosetting plastics to serve as fuel-binders.

Processing

The first step in processing involves conditioning the raw solid materials. Some operations are: purification, chemical treatment, drying, grinding, screening. One of the most important of these operations is grinding. In order to provide the highest possible propellant density, it can be seen that all particles should be as close together as possible. With the use of the aggregate analogy in concrete, a combination of coarse and fine particles will produce the greatest density and strength. In the selection of a grinding method the desired particle size and shape and the time allowable for the operation must be considered. Ball mills can produce a large variety of particle sizes but they are relatively slow. High-speed hammer mills generally produce the smallest particle sizes with the greatest speed. From the safety standpoint the reductant and oxidizer should always be ground separately. In the potassium perchlorate oxidants commonly used in JATO, for example, about 50% of the oxidizer is below 60 μ and about 50% is in the 100-60-μ range.

In metering solid propellant materials, the batch technique is to be considered optimum from the standpoint of accuracy and safety. Some processes, however, should be amenable to continuous flow techniques.

Before the final mixing takes place, it may be desirable generally to mix all solids together and all liquids together. However, this may not be feasible with certain propellants for reasons of safety or prolonging "pot" life. Solids can be blended by simple mixing and miscible liquids can also be blended in this way. However, immiscible liquids may have to be blended by the use of special techniques to produce colloidal mixtures.

The final mixing of all materials may be done under a wide variety of heat and pressure conditions. Usually this phase of operations is to be regarded as having the greatest hazard since all materials are present for the first time. Mixing is continued only long enough to insure production of a uniform mixture. The acquisition of a uniform mixture is mainly a function of the nature of the materials being mixed, the type of mixer, and the length of the mixing period. At best, determination of a processing procedure is an empirical operation.

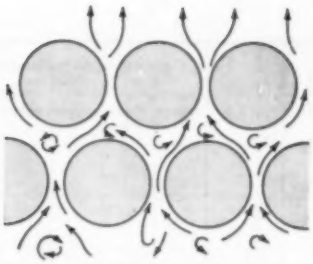
The final operation will depend largely on the nature of the mixed propellant which may vary in consistency from a fairly viscous liquid to a doughlike mass. For fluid or "castable" mixtures, the propellant can be poured into molds or the waiting rocket motor. The casting operation may be performed under a vacuum or under pressure and agitation to avoid bubbles and voids. For drier mixtures pressure casting or compression molding may be necessary. A fusion or "cure"-type heat application is necessary then to convert the mixture to a solid.

Safety

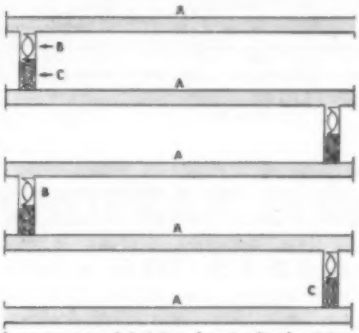
It is perhaps fortunate that the solid propellant industry has stemmed from the explosives field. Although processing techniques may be somewhat different, safety aspects have in most cases been similar. All operations are to be considered hazardous and may range from those dealing with a flammable solid to those dealing with a near high explosive.

As far as possible, all operations are performed remotely. Where crews are necessary, protective shielding is provided. Operations are separated in accordance with quantity-distance techniques prevailing in the explosives field. Generally all work involves the use of the smallest possible quantities of materials. All explosive or flammable materials not being used in the process are kept away from processing areas. It is important to keep things clean. Operations involving production of heat, sparks, or pressures are avoided. Workers are stringently required to conform to standard rules and regulations. For these reasons the propellant industry has earned a high level of safety.

Presented at A.I.Ch.E. meeting, Louisville, Ky.



Packed reactor. Uniformity of residence times is approached by the splitting and intermingling of small flow elements, permitting statistical averaging of widely varying residence times in short passages. Flow upward if density decreases, and vice versa.



Tubular reactor minimizing longitudinal mixing. Mixing devices between sections are to destroy flow pattern established in tubes at low velocities. A. tubular reactor. B. helices. C. packing.

CONTINUOUS-FLOW REACTORS — the problem of variable residence times

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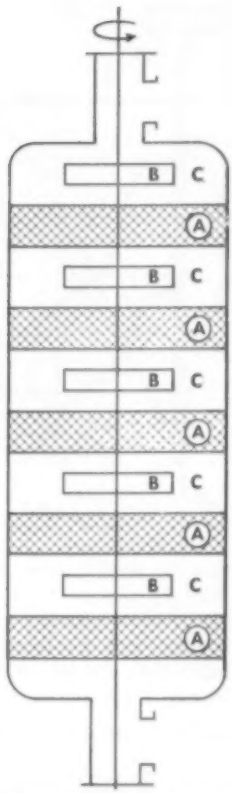

Reactor consisting of alternate packed sections and mixing chambers, simulating a series of separate stirred reaction vessels. A. layers of ceramic rings, screens, glass fibers, knitted wire cloth, or other packing. B. paddles fixed to axial rotating shaft. C. mixing chambers. Flow upward if density decreases and vice versa.

The failure of commercial continuous-flow reactors to give the same results as laboratory batch tests appears to be explainable in many instances on the basis of the wide range of residence times in the flow reactor. This is due to mixing and "short-circuiting" of parts of the fluid stream.

If a fluid passes continuously and at a steady rate of F lb./min. through a reactor having a capacity of M lb., then the "nominal holding time" or "nominal residence time" is M/F min. Probably every chemical engineer knows that some of the fluid passes quickly through and that other portions remain in the reactor for varying lengths of time. Yet it is not uncommon to find this point overlooked in designing equipment. The result is that the expected chemical conversions are not realized.

An example is a first-order liquid-phase reaction which is found by laboratory batch tests in ampoules to attain a maximum of 60% yield of the desired product, in, say, 20 min. The product tends to decompose under the reaction conditions, so that at the end of 50 min. the yield is almost back to zero. The yield-time relation is illustrated by Curve A of Figure 1.

The maximum yield per pass would be attained if a reactor could be designed to hold all parts of the feed 20 min., and no more, but some of the fluid stays in the reactor 5 min. and some 40 min., and the resulting average yield may be much less than the maximum found in the batch tests. The effect of variation of residence time is not trivial. For example, if a single well-stirred vessel were used as a continuous-flow reactor, the average yield per pass in the case of a sequence of first-order reactions, as illustrated by Figure 1, would be 30%, as compared with the maximum of 60% attainable at the optimum nominal residence time.

An analysis of the importance of variable residence time requires information on two separate aspects of the problem —the yield as a function of time, and the residence-time distribution for the reactor. The first is usually determined by batch tests in the laboratory and may involve a maximum, as in Curve A of Figure 1, or approach an asymptote, as in Curve B.

The residence-time distribution is known for a few reactor designs (*1, 2, 6*), see Figure 2. The ordinate P represents the probability that an element of the feed will be retained a time θ, and the abscissa T is the ratio of the residence time θ to the nominal residence time, M/F. More specifically, $\int_{T_1}^{T_2} P dT$ is the fraction of the feed stream that is retained for a time between θ_1 and θ_2. Ideally, the fluid would move through the reactor like the motion of a piston, giving so-called plug flow, and all elements would have the same residence time, M/F, i.e., $T = 1$. This seems to be unattainable in practice.

With reference to Figure 2, Curve A shows the residence-time distribution for steady flow through a well-stirred vessel, the effluent having the same concentration as the stirred fluid. In this case short-circuiting is very serious, since much of the feed passes through quickly. If two stirred vessels in series are employed, the fluid which passes rapidly through the first has a chance of being retained a long time in the second, and the spread of total residence time is reduced. As shown by Curves B and C, however, five or even twenty stirred vessels in series (*6*) do not give narrow peaks in the curves of P vs. θ or T. For the hypothetical sequence of first-order reactions illustrated by Curve A of Figure 1, the average yield by use of 1, 5, and 20 stirred reactors would be 30, 47, and 57%, compared with the peak of 60%. Average yield for a first-order reaction is the integral $\int_0^\infty PC dT$, where C represents fractional yield. The yields to be expected in multiple stirred vessels have been worked out for chemical reactions of known orders (*3, 4, 6*).

For the case of a higher order reac-

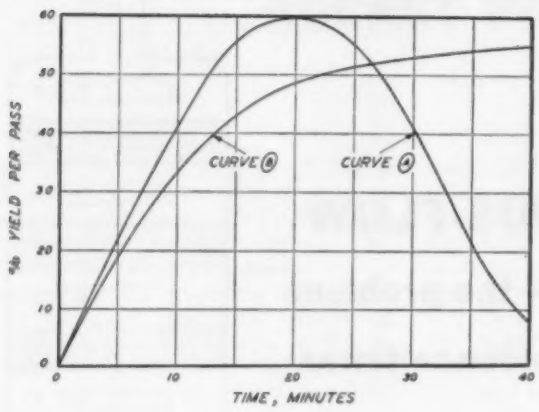

Fig. 1.

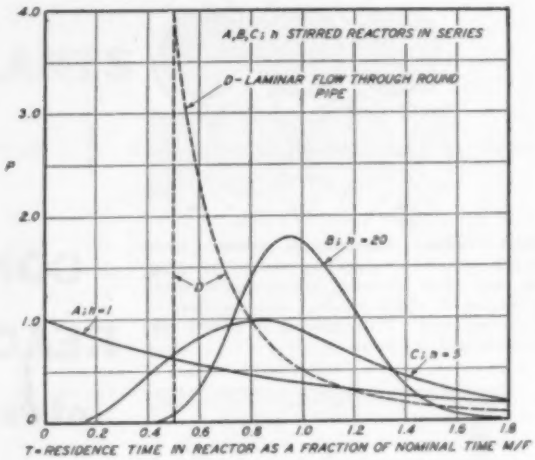

Fig. 2.

tion the yield depends on the concentrations of two or more reactants which may follow different paths through the reactor, and information on yields in batch tests and on residence-time distribution is inadequate. Strictly speaking, the evaluation of yield as $\int_0^\infty PCdT$ is valid only when rate of formation of a product is proportional to the amount, rather than the concentration, of the reactant. In well-stirred vessels the yield may be calculated directly from the volume, nominal residence time, and concentrations of reacting materials, no matter what the order of the reaction. For first-order reactions this procedure gives the same result as $\int_0^\infty PCdT$. Gilliland, Mason, and Oliver (*5*) have shown that for more complicated reactions the yield generally falls in between that calculated as $\int_0^\infty PCdT$ and that arrived at on the assumption of complete mixing.

The reactor might consist of a long tube through which the fluid passes at a constant rate. If the desired reaction time is measured in minutes, the flow rate will necessarily be low, in which case the flow will be laminar, and the residence-time distribution will be (1), as illustrated by Curve D of Figure 2. No fluid will get through in less time than corresponds to the velocity at the center line, but the rest will lag. The equation connecting P and T is

$$P = \frac{1}{2T^3}; \quad \left(T > \frac{1}{2}\right) \qquad (1)$$

The spread of distribution time is relatively narrow, but the tube length will be excessive for most commercial flow rates if the holding time is to be several minutes. The residence-time distribution looks better for turbulent flow (*2*) because the velocity profile in the tube is flatter, but the tube lengths are even more apt to be excessive because of the higher linear velocities.

If stirred reactors give poor results and straight tubes are impractical, how can reactors be designed to give a narrow range of residence times?

The principles are simple: lateral mixing is beneficial; longitudinal mixing is detrimental. Tubular reactors may be fitted with baffles or stirrers to accomplish radial mixing every few inches or feet, perhaps with screens or packing between mixing points to minimize longitudinal mixing. Reactors packed with spheres, rings, or broken solids may be used with flow upwards if density tends to decrease, and vice versa.

Whatever the design, it is possible to obtain the residence-time characteristics by a simple experimental procedure.

With the device operating at steady flow, let an amount of color, caustic, or other tracer be suddenly introduced at the feed point. Then let the effluent be analyzed at successive short-time intervals, care being taken to obtain samples which are truly representative of the stream at the instant sampled. The curve of tracer concentration in the effluent vs. time will be the equivalent of the P-T curve, being related by

$$\text{Concentration in effluent} = PW_T/F \qquad (2)$$

$$\text{and time} = \frac{MT}{F} \qquad (3)$$

where W_T is the weight of tracer added.

This simple test may be employed to determine the flow characteristics of any existing reactor. The residence-time distribution may be obtained also by measuring the effluent concentration as a function of time after the feed concentration has been changed suddenly to a new constant value (*3, 5*).

The problem of residence-time distribution shows up in many types of reactors. In some cases it is not serious, as when the yield is approaching an asymptote (Curve B of Figure 1). The average of a range of yields along the right-hand end of the curve is little lower than the yield at the nominal holding time. In cases of chain or sequential reactions, as in the oxidation of hydrocarbons, the spread of residence time leads to a "smear" of products in place of the desired high yield of a single compound. In the manufacture of acetylene from natural gas the production of an effluent containing both carbon and unreacted hydrocarbon is due in part to the fact that some of the feed mixture has not been heated long enough while other portions have been overheated. The problem appears to be common to steady-flow reactors for both gases and liquids in many different kinds of processes.

Notation

C = fractional yield/pass through reactor actor
F = flow rate, in and out, lb./min.
M = capacity of reactor, lb.
P = relative probability that an element will be retained for a time between θ and $\theta + d\theta$
$T = F\theta/M$ = fraction of nominal residence time
W_T = weight of tracer added, lb.
θ = residence time of an element of fluid, min.

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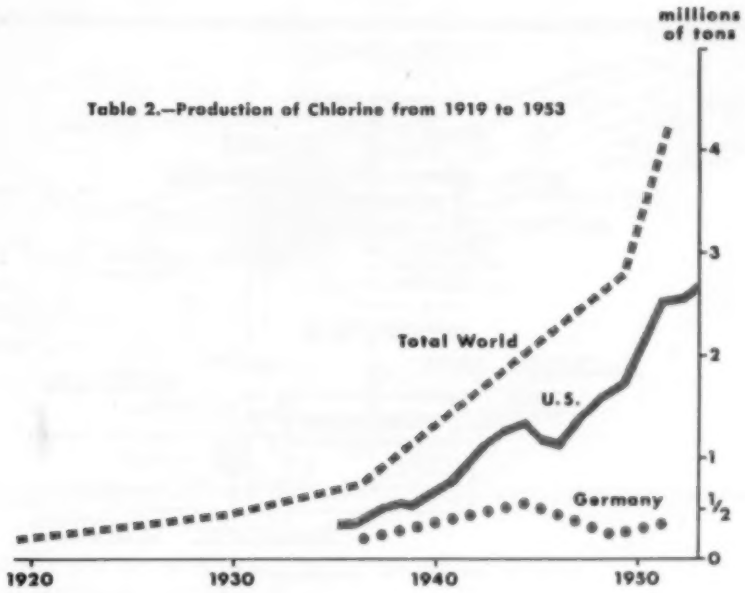

EUROPEAN designs of ELECTROLYTIC cells for CHLORINE and CAUSTIC

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The use of chlorine in the manufacture of paper, plastics, textiles, automotive fluids, solvents, detergents, insecticides, refrigerants, pharmaceuticals, and sanitary products indicates its importance to society (29). Initial production of chlorine in various countries in 1951 is shown in Table 1 (*14*). These data reveal that the United States led in manufacturing 60% of the total world production, followed by Germany, Great Britain, France, and Japan.

For sixty years chlorine has been produced almost exclusively by the electrolysis of sodium chloride brine. Table 2 gives a picture of the rapid growth in the world production. Within the last twenty years world production has increased ten times.

Table 1.—Chlorine Production in 1951

Total World Production, 4,180,000 tons

Country	tons	lb./ capita
United States	2,518,000	33.0
Germany { Western = 282,000 / Eastern = 139,000 }	421,000	12.8
Great Britain	385,000	16.7
France	143,000	7.1
Japan	143,000	2.7
Canada	106,000	20.6
Sweden	83,000	25.2
U.S.S.R.	77,000	0.8
Italy	65,000	2.8
Netherlands	34,000	8.6
Argentine	21,000	4.7
Norway	20,000	12.8
Finland	19,000	10.3
Austria	14,000	4.0
Belgium	13,000	3.7
Brazil	13,000	0.8
Spain	12,000	0.9
Switzerland	11,000	5.2
Czechoslovakia	11,000	1.8
China	11,000	0.05
Australia	9,000	2.5
Hungary	9,000	1.9
Poland	9,000	0.8
Chile	8,000	4.0
India	8,000	0.05
Rumania	6,000	0.8
Yugoslavia	6,000	0.8
Egypt	2,000	0.3
Formosa	2,000	0.6
Turkey	2,000	0.3
Colombia	1,000	0.3
Peru	1,000	0.6

Cell Design

ECONOMIC FACTORS

With each ton of chlorine produced by electrolysis, 1.12 tons causic soda and 56 lb. hydrogen are obtained as by-products. In former years the demand for caustic was higher than for chlorine, but the apparent need has been reversed in recent years. One important economic factor is the profitable disposal of the by-products. Another fundamental requirement is the compact design of the electrolytic cell to save building space.

DIAPHRAGM AND MERCURY CELL

Electrolysis is carried out either in a diaphragm or in a mercury cell (shown schematically in Figure 1). Two structural differences characterize the two types: the diaphragm cell is separated into two compartments, whereas the mercury cell has only one through which mercury is circulated. In the diaphragm cell chlorine gas leaves the anode chamber, and hydrogen and a weak caustic liquor, contaminated with nonreacted brine, leave the cathode chamber. In the mercury cell chlorine and sodium amalgam are formed. The latter is transferred into a decomposer where it is reacted with water forming a concentrated caustic liquor and hydrogen. The decomposed mercury is recycled to the electrolyzer.

It is interesting to note that the United States and Germany went different ways in the development of electrolytic cells. Until a few years ago the United States produced 89% of its chlorine in diaphragm cells (*15, 40*), whereas 65% of the German chlorine was made in mercury cells (*26*). In

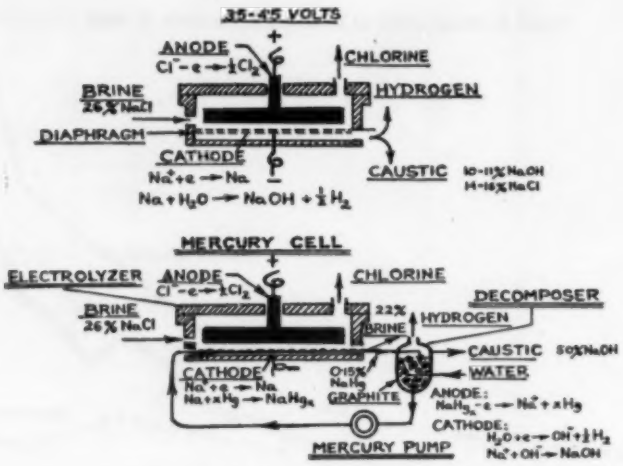

Fig. 1. Diaphragm cell

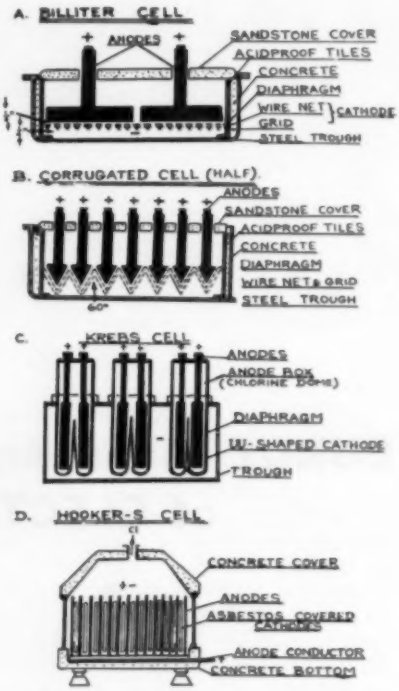

Fig. 2. Diaphragm cells, cross section.
A. Billiter cell.
B. Corrugated cell (half).
C. Krebs cell
D. Hooker-S cell.

the last five years, production of chlorine in mercury cells in the United States has increased from 5 to 15% by the employment of mercury cells of original German design.

European Designs of Diaphragm Cells

On the European continent the Billiter diaphragm cell enjoyed widespread use but has been virtually replaced by the mercury cell. During the last war asbestos fiber for the diaphragm cell became scarce, whereas mercury was readily available from Spain.

BILLITER CELL

The Billiter cell (Figure 2A) consists of a shallow steel trough lined at the side walls with concrete or acidproof tiles (*31*). The cathode, a grid 3 to 4 in. above the bottom, supports the diaphragm. The diaphragm is prepared from a mixture of long fiber asbestos with barium sulfate. The anodes are spaced about ⅓ in. above the diaphragm. The electric current is supplied to the anodes by copper or aluminum bus bars and to the cathode by direct connection to the cell casing.

The cell operates at 160 to 185° F. The almost saturated brine is fed continually to the cell, and the level is controlled automatically. The caustic liquor which collects below the cathode is discharged continually through siphons. The chlorine leaving the cell contains only .01 to .33% H_2. The hydrogen gas from the cathode chamber is 100% pure.

CORRUGATED BILLITER CELL

To increase the production per unit floor space by 50%, a modification of the flat horizontal Billiter cell was designed with wedge-shaped anodes (Figure 2B). This cell represents the intermediate between the horizontal and the vertical cell types (*35*).

KREBS DIAPHRAGM CELL

The Krebs cell is illustrated in Figure 2C. Three W-shaped perforated cathodes are placed into the cell trough and covered with a diaphragm. Fifteen pairs of graphite anodes supported by the anode boxes are fitted above the diaphragm. As the cell operates unsealed, the anode gas contains 30-40% air. As the design, piping, and maintenance are more complicated, this cell was abandoned in most European plants. For a comparison, the principle of the American Hooker cell is shown in Figure 2D. It consists of two rows of graphite anode blades mounted vertically in a concrete trough. Flat wire envelopes with the diaphragm extend inward from the side walls between each anode (*18, 19*).

A comparison of the dimensions and performance of the three European cells and the American Hooker cell is given in Table 3. The advantages of the Hooker cell over the European cells are: (a) smaller size, (b) higher production per unit floor space, and (c) lower voltage and higher current efficiency (*28*).

European Designs of Horizontal Mercury Cells

The horizontal mercury cell is preferred over the diaphragm cell where highly concentrated pure caustic is required for the rayon industry. It is the predominant design in Europe but was not popular in this country until recently, although the first mercury cell was invented by an American, H. C. Castner, 62 years ago. The three main sections of the European mercury cell—electrolyzer, decomposer, and mercury pump—are described here.

1. THE ELECTROLYZER

The electrolyzer is a long horizontal trough with a cover through which the anodes are suspended (Figure 3). The brine and mercury are flowing cocurrently through the electrolyzer which is separated from the decomposer by an end box. The latter serves (a) to prevent mixing of the chlorine and hydrogen gas, and of the

nonreacted brine with the caustic liquor, and (b) to reduce the velocity of the amalgam so that contaminants can float to the surface and be skimmed off.

The chlorine gas is removed under suction either through the cover or discharged simultaneously through the brine overflow and separated in a single or central separator. During the electrolysis the mercury picks up 0.1 to 0.2% Na, and the brine decreases from 26 to 22%. If the brine would decrease more, the hydrogen content of the chlorine, which is generally between 0.3 to 1%, would increase because of the electrolysis of water. Other methods to increase hydrogen content are: (a) by raising the current too rapidly in a newly started cell, (b) by raising the temperature above 200° F., so that salt can crystallize, drop into the mercury, and expose the steel cathode conductor, (c) by avoiding contaminations, such as vanadium in the anodes, which reduces the hydrogen overvoltage. The graphite anodes are shaped like those of the Billiter cell and spaced ¼ in. above the mercury surface.

The horizontal cells may be classified by two design groups: the single cathode-conductor type (Leverkusen) and the multiple cathode-conductor type (Ludwigchafen) (*1, 4, 13, 20, 23, 24, 32, 35, 41, 42, 43*). The distinction is that in the single cathode-conductor type the bottom of the electrolyzer is a bare steel plate, whereas in the multiple cathode-conductor type, a series of discs or bars extends through the rubber- or stone-lined bottom.

Multiple Cathode Conductors

Multiple cathod conductors are illustrated in Figure 4. The British mercury cell of the International Electrolytic Plant Company and the Italian and American De Nora (*2,22*) cells are modifications of the German Ludwigshafen type. The troughs are made either of a horizontal I-shaped steel beam or are U shaped. The troughs of the German and British cell are rubber or PVC lined, whereas the De Nora cell is covered with a resistant stone such as syenite. The trough of the standard Ludwigshafen electrolyzer is furnished with 24 steel discs, 8-in. diam., and mounted flush. The cell has a slope of 1 to 2 in. and the mercury circulates at a depth of 0.08 in. The British cell has the same arrangement. A disadvantage of the rubber lining around the discs is that mercury may leak around the discs and lift the rubber from the steel bottom. In the De Nora cell the cathode contact consists of transverse steel strips between which the stone lining is grouted and the joints sealed with a cement resistant to the service encountered. The rubber-lined steel cover of the Ludwigshafen cell serves as the electric conductor between the bus bars and the anode cable, whereas the British and the De Nora electrolyzers have separate connecting strips.

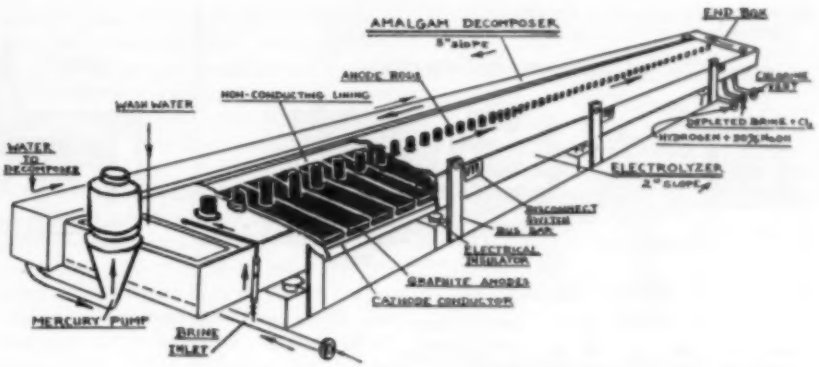

Fig. 3. Mercury cell, perspective view.

Single Cathode Conductors

Electrolyzers with the single cathode conductors have become the most common type in Europe during the last ten years. The trough is made either of a horizontal I beam with a bare steel bottom (Figure 5A) or fabricated from a machined bottom plate bolted to a frame (Figure 5B). The frame type is less expensive, but leakage may occur at the gaskets.

electrolysis

The American Mathieson electrolyzer (Figure 5D) is also of the frame type (*12, 33*). Its bottom plate is made of channel steel which provides a wider joint with the frame and prevents leakage.

Table 3.—Diaphragm Electrolytic Cells

		Billiter Cells		Corrug. Billiter Cell	Krebs Cell	Hooker Cell		
		Oblong Germany	Square Germany	Germany	Germany France	S U.S.A.	S-3 U.S.A.	S-3A U.S.A.
Dimensions	length ft.	21½	14½	14½	7½	5	6½	5½
	width ft.	5	10	10	4¾	4	5½	6½
	height ft.	1½	1¾	1¾	1½	6	7½	7½
Electric Power	amp.	6,000	10,000	15,000	6,240	8,000	20,000	24,000
	v.	4.5-5.0	4.3	3.9	5.0	3.48	3.65	3.85
	efficiency %	94	94	94	88.4	96.0	96.0	96.0
	anode dens. amp./sq.in.	0.806	0.686	0.543	....	....	....	....
	cathode dens. amp./sq.in.	0.61	0.645	0.516	0.40	....	....	....
Consumption/ton Chlorine	power kw.-hr.	3,700	3,280	3,200	3,870	2,690	2,610	2,760
	NaCl lb.	3,640	4,200	3,920	....	3,440	....	....
	graphite lb.	8.5-20	13.0	16.9	....	6.7	6.9	6.9
NaOH in Liquor	%	9.1	11.0	11.0	11.5	11.3	11.65	11.8
Floor Space	lb. Cl_2/ sq.ft./day	—	5.1	7.7	....	9.0	15.7	18.9

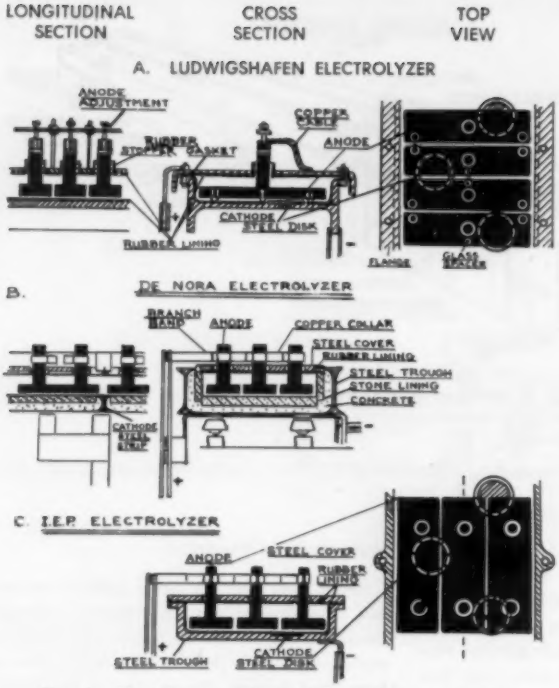

Fig. 4. Electrolyzers with multiple cathode conductors.
A. Ludwigshafen electrolyzer.
B. De Nora electrolyzer
C. I.E.P. electrolyzer.

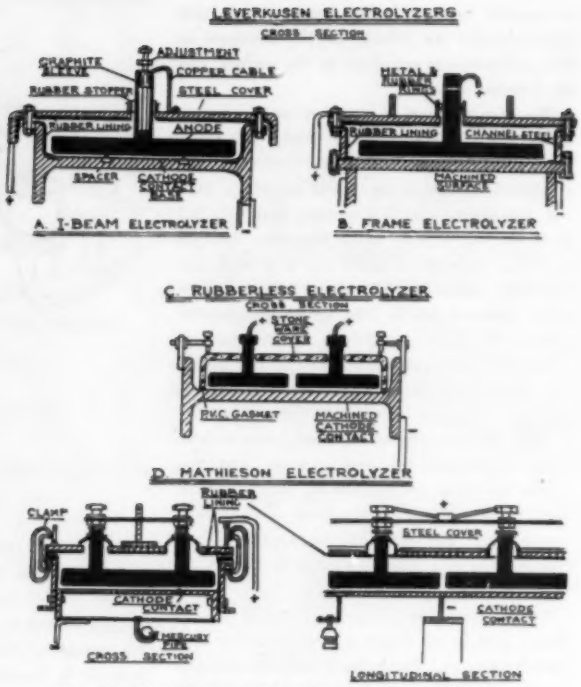

Fig. 5. Electrolyzers with single cathode conductors

The bottom plate, which has small grooves in the corners to prevent contraction of mercury, must be machined absolutely flat. The side walls are rubber lined. The covers are either single or sectional units and are either rubber lined or made of stoneware or sandstone. During the war when rubber became scarce, the Wacker Chemie developed a rubberless electrolyzer (Figure 5C), the cover and side walls of which are a single stoneware unit, bolted down to the cathode steel plate. Another development of Wacker was to fabricate the anode stems of metal and to insulate them with PVC tubings. Thus, the conductor potential was reduced slightly.

Essential data of the different horizontal mercury cells are presented in Table 4. The important factor of producing the highest amount of chlorine per unit floor space is given in the last line. This can be accomplished either by building the cell (electrolyzer and decomposer) compactly or by increasing the nominal load. Increasing the nominal load requires disproportionately higher voltage and results in less efficient utilization of power (2). The American Mathieson cell operates at a higher current density than the others. The American, British, and Italian cells have a higher production per unit floor space than the German cells owing to the difference of the amalgam decomposers.

Table 4.—Horizontal Mercury Cells

		Cells with Multiple Cathode Conductors					Cells with Single Cathode Conductor		
		Ludwigshafen Type			De Nora		Leverkusen Type		Mathieson
		Small Germany	Large Germany	I.E.P. Brit.	Italy	Monsanto U.S.A.	Small Germany	Large Germany	E-8 U.S.A.
Dimensions	length ft.	16¾	23	22	35	47	23	46	35
	width ft.	2¼	2¼	2	2	3	2½	2½	2
	height ft.	¾	¾	¾	½	¾	¾	¾	½
Electric Power	number of anodes/cell	20	40	24	42	96	38	74	22
	amp.	8,000	16,000	7,500	15,000	30,000-36,000	15,000	20,000-28,000	30,000
	v.	4.6-5.1	4.5-5.0	4-4.3	4.1-4.15	4.5	45-5.0	4.8-5.1	4.5
	efficiency %	94.9	94.9	90.8	92.2	95	95	94	95
	anode dens. amp./sq.in.	2.2	2.2	....	1.43	....	2.1	2.12	3.1
	cathode dens. amp./sq.in.	1.69	1.67	....	....	1.62-1.94	2.1	17-21	....
Consumption/ton Chlorine	power kw.-hr.	3,860	3,920	3,280	3,200	3,200	3,500	3,500	3,240
	NaCl lb.	4,200	3,640	3,310	3,550	3,400	3,380-3,600	3,350-3,560	3,400
	graphite lb.	8-10	5.4-10	7	7	5	8-11	9-12	6
	mercury lb.	0.5-0.9	0.2	0.25	0.25	0.4	0.4	0.57	0.56
Mercury/cell	lb.	....	....	1,100	1,800	3,500	900	1,700	1,900
Floor Space	lb. Cl_2/ sq.ft./day	4.1	4.3	10.0	6.1	....	4.1	4.1	7.8

2. AMALGAM DECOMPOSER

There are two types of decomposers for the manufacture of caustic and hydrogen: the horizontal and the vertical. The horizontal decomposers are either closed rectangular troughs or cylindrical tubes (Figure 6A) parallel to the length of the electrolyzer. The amalgam coming from the end box flows countercurrent to a stream of water. The sodium amalgam reacts with the water on graphite grids and forms a 50% caustic and hydrogen gas. The caustic is discharged through an overflow, and the hydrogen leaves by its own pressure through the cover or simultaneously with the caustic and separates later. Between 82-95% of the hydrogen evolved is recovered.

The German decomposers are about 10 in. wide with a pitch of 3 to 5 in. rubber lined or of cast steel. The British cells are furnished with two smaller decomposers in parallel underneath the electrolyzer (Figure 6B), and though this design allows the most saving of floor space, it makes the decomposers less accessible.

A 70% caustic is required for special applications and is made in an insulated decomposer of 36-ft. length and operated at 220° F. The sodium content of the amalgam is increased to 0.3% but should not exceed more, otherwise, the amalgam gets too viscous and the evolution of hydrogen in the cell may become too great. A too high content of sodium is due mostly to inactive grids or to the accumulation of dust or grime.

The vertical decomposer consists of a tower packed with graphite lumps (Figure 6C). The amalgam enters at the top and flows downwards countercurrent to a stream of water. The depleted mercury drains from the bottom and returns to the electrolyzer. The caustic and hydrogen are discharged at the top. Advantages of the vertical decomposer are: (a) less floor space is required, (b) its size is independent of the electrolyzer length, (c) it is less dependent on current load because of smaller heat loss by heat radiation, and (d) amalgam decomposition is more complete, even at a smaller load. On the other hand, more power is required to pump the mercury to the top of the decomposer or back to the electrolyzer. Approximately 200 lb. Hg/1 lb. of 50% caustic must be pumped against a head of a few inches in a horizontal decomposer, but against a head of several feet in a vertical decomposer.

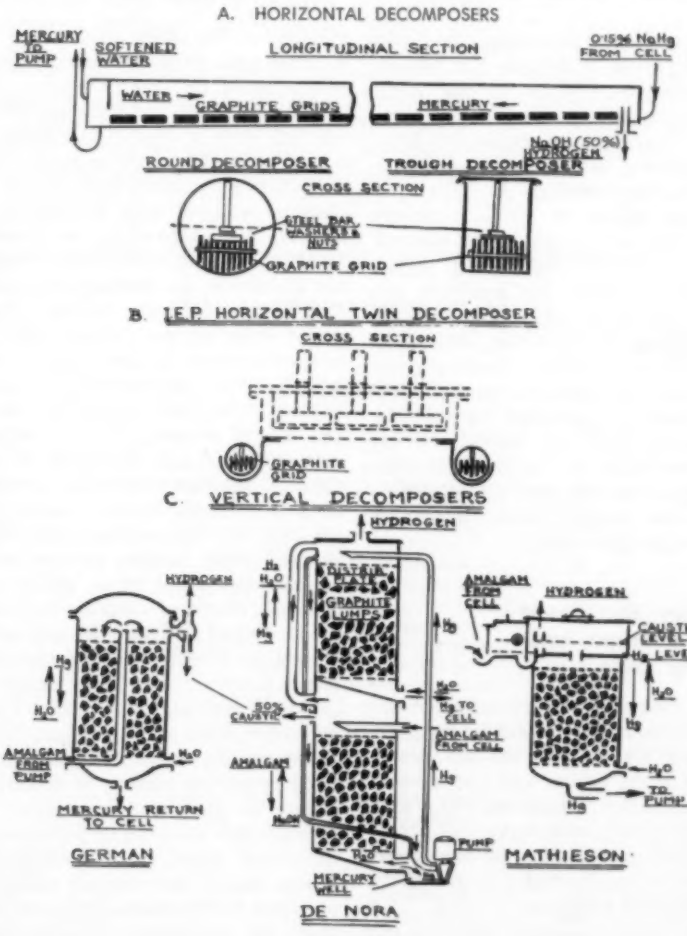

Fig. 6.

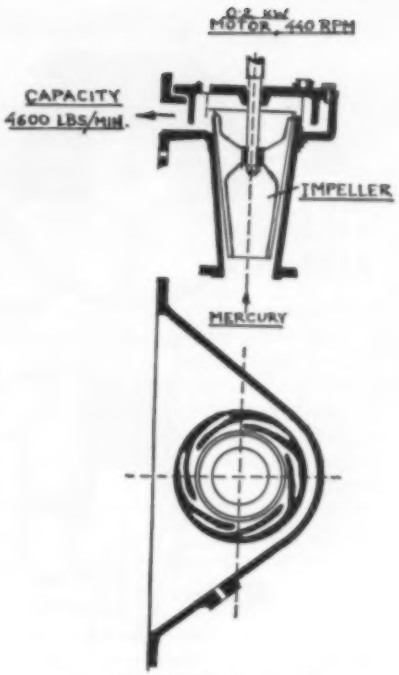

Fig. 7. Mercury pump.

electrolysis

The first vertical decomposer was installed at Hoechst but abandoned because the graphite was abraded and had to be replaced frequently resulting in excessive mercury loss. The caustic contained graphite particles and 5 mg./1 Hg. However, an improved decomposer is in use in Germany on the vertical mercury cells and on the horizontal De Nora and Mathieson cells. The De Nora cell has a two-stage tower decomposer (8 ft. high) for the production of 50% caustic. One of the two stages of the decomposer is steam jacketed when producing 70% caustic. The standard Mathieson decomposer is only 3 ft. high. The discharged caustic is sent through a nickel-plated filter press to remove the graphite dust.

3. THE MERCURY PUMP

The standard European mercury pump is a centrifugal pump as illustrated in Figure 7. It consists of a rotating cone with vanes inside. The impeller operates at 440 rev./min. and at a capacity of 4,700 lb. Hg/min.

European Designs of Vertical Mercury Cells

The vertical rotating mercury cell (Figure 8) was designed by W. Honsberg, Ludwigshafen, to save floor space. Three times more chlorine is produced

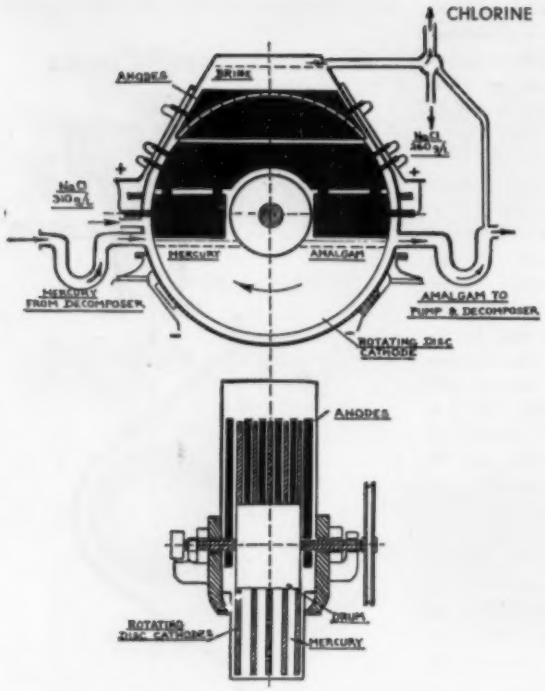

Fig. 8. Vertical rotating disc mercury cell.

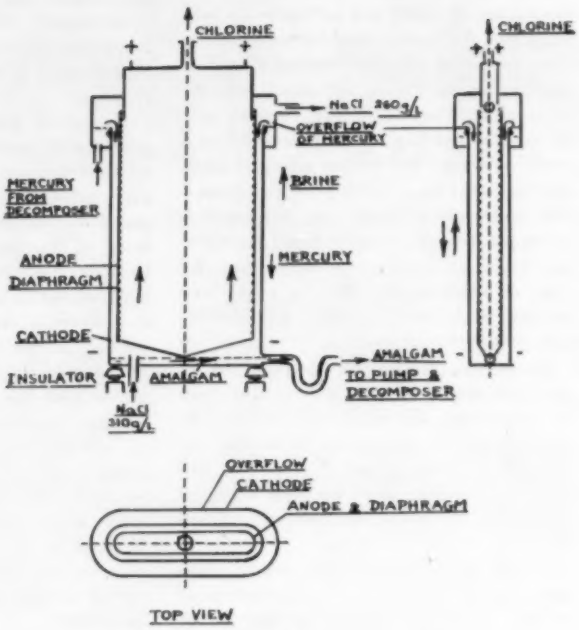

Fig. 9. Vertical stationary mercury cell.

per square area than in the horizontal cell. The electrolyzer is a rubber-lined curved trough with a cover. Four or five vertical steel discs rotate slowly between stationary graphite anodes suspended from the cover. The lower halves of the discs are immersed in mercury and pick up sufficient mercury on their amalgamated surfaces to act as mercury cathodes. The sodium chloride brine enters the cell cocurrent with the mercury and fills the upper half of the cell. A larger amount of mercury is required because the cell is filled with mercury to a height of 2½ ft. In order to reduce the amount of mercury, it is displaced by a rotating drum or partitions extending from the cell bottom (*5*). Essential data and dimensions are summarized in Table 5. The cell size is limited because the diameter of the discs cannot be enlarged; otherwise the amalgam coat would be thrown off by centrifugal forces. The disadvantages of this type are: (a) the anodes are not adjustable laterally, hence the voltage increases by 0.2 v./month operation, (b) the magnetic distortion of the rotating discs, and (c) partial short-circuiting at the anode contact due to the brine leakage.

A second way of gaining floor space is to carry out the electrolysis in a vertical stationary cell, developed at Wolfen and Bitterfeld (Figure 9). It consists of an elliptical tank, 6½ ft. high (*8*). The side walls serve as a cathode conductor. Mercury overflows from a trough around the top of the tank. A mercury film covers the inside wall. The brine is fed into the bottom and passes (in contrast to the other cells) countercurrent to the mercury film and leaves the cell in an overflow. The cylindrical, perforated anode is arranged in the interior. A diaphragm of porous rubber or PVC is placed between the two electrodes to prevent reaction of the chlorine, formed in the lower section, with the amalgam reforming sodium chloride. This cell has the advantage of requiring little floor space, but it has these disadvantages: (a) difficulty in anode adjustment, (b) greater power consumption for pumping the mercury, and (c) inability to increase the height of the mercury film. At a height greater than 6½ ft. turbulence of the mercury results in tearing loose the amalgam film.

Auxiliary Equipment for Diaphragm and Mercury Cells

A chlorine plant employing diaphragm cells differs from one employing mercury cells not only in the cell design but also in the design and arrangement of the auxiliary equipment. The auxiliary equipment must serve (a) preparation and purification of the brine, (b) electric supply, and (c) processing of the finished products.

Plants with diaphragm cells can utilize solid salt, as well as concentrated brine derived from sea water or wet mining; on the other hand, plants with mercury cells require solid salt for the saturation of the recycle brine.

The diaphragm and the mercury cells are fed with a 26% NaCl brine, the concentration of which decreases to 14-16% during the electrolysis in the diaphragm cell, but only to 22% in the mercury cell. Therefore, the quantities of brine handled, stored, and circulated are greater in the mercury-cell process than in the diaphragm process. The recycled brine of the mercury cell must be dechlorinated before it can be resaturated. The dechlorination prevents (a) excessive loss of valuable chlorine, (b) hazard to operators, (c) excessive corrosion, and (d) formation of hypochlorite. The dechlorination procedure is as follows: the brine is acidified to a *p*H of 3 with hydrochloric acid and degasified under vacuum and by blowing air countercurrent in a spray tower. The last traces of chlorine or chlorate are destroyed by adding a small amount of sodium bisulfite. The dechlorinated brine is neutralized with caustic and resaturated by adding solid salt. Certain impurities, such as magnesium, calcium, heavy metals, and sulfate are precipitated by adding barium or sodium carbonate to the dissolving vessel. The precipitate is removed by filtration. The impurities would cause hydrogen discharge in the mercury cell almost proportional to their concentration or would block the diaphragm in the diaphragm cell, thereby causing contamination of the final caustic.

An adequate supply of direct current is obtained either from d.-c. generators or from transformed and rectified three-phase current (*21, 25, 27*).

The European processing of the produced chlorine and hydrogen gas is similar to that employed in this country (*36*). The chlorine gas from the mercury cells contains 0.3 to 1% H_2. To avoid explosions, only ¾ of the chlorine are compressed and liquefied. The last quarter has to be used uncondensed in the plant. The hydrogen gas from the mercury cells carries 1½ to 2½ mg./cu. ft. Hg. Half of this amount is condensed in a cooler, and the gas may then be used in the synthetic ammonia process, but the remaining mercury still causes trouble as a poison for hydrogenation catalysts and accelerates corrosion of light metal alloys. For these applications the hydrogen is purified by ammonia or carbon dioxide refrigeration, chlorine water treatment, or activated carbon adsorption.

The outstanding feature of the mercury-cell process is the high grade and concentration of the caustic liquor. This product may be used without further treatment in the rayon industry. A typical analysis of the caustic is shown in Table 6.

The 10 to 11% caustic liquor of the diaphragm cell contains 14 to 16% caustic soda. It is concentrated and separated in three-stage evaporators to 27% and converted to 50% caustic in a vacuum concentration (*38*). This caustic would have to be purified for the application in the rayon industry. The U. S. practice of ammonia treatment was considered in Europe to be too expensive to compete with the caustic produced in the mercury cells.

Chlorine without Caustic Soda

The rapidly increasing demand of chlorine brought the desire to produce chlorine without caustic soda. There are three ways to do this:

(1) to electrolyze other alkali salts

(2) to convert the sodium amalgam of the mercury cell into valuable products

(3) to oxidize or electrolyze hydrogen chloride.

(1) The electrolysis of potassium chloride is carried out in the same way as the electrolysis of sodium chloride. The mercury-cell process is considered more economical than the diaphragm-cell process, because the latter requires caustic potash concentrators one third larger than the caustic soda concentrators (*11*). A disadvantage of the mercury-cell process is the 1% lower current efficiency as the consequence of the wider spacing between the electrodes. The anodes have to be kept ⅓ in. above the mercury level because potassium amalgam is more active than sodium amalgam.

Table 6.—Caustic Liquor from Mercury Cells

	%		%
NaOH	50.0	SiO_2	0.02
NaCl	0.02–0.1	Al_2O_3	0.012
Na_2CO_3	0.15–0.3	Fe	0.001–0.008
Na_2SO_4	0.004–0.2	Hg	0.00007
CaO	0.02		

(2) Sodium amalgam may be used in the synthesis of various chemicals. It is converted into sodium methylate or ethylate by adding methanol or ethanol instead of water to the decomposer. A major application for sodium amalgam is as a reducing agent. The decomposer is replaced by a nickel-lined agitated kettle through which the amalgam circulates. Examples of reduction are the conversion of nitrobenzene to azo and hydrazo benzene, substituted nitrophenol and nitroanthraquinone to dye-stuff intermediates, and ketones to pinacone. In a glass-lined kettle sodium bisulfite is reduced with sodium amalgam to sodium hyposulfite or in the standard decomposer sodium polysulfide to sodium sulfide (*3, 6, 30, 39*).

electrolysis

H. N. Gilbert of Du Pont found that sodium amalgam can be converted into metallic sodium by electrodeposition. An improved process is in operation at Lechchemie, Gersthofen (*7*). An amalgam containing 0.2 to 0.3% is produced in a standard horizontal mercury cell and transferred through a heat exchanger to a rotating disc cell of the Honsberg type where the electrodeposition takes place. The cell is furnished with rotating nickel discs, operates at 1½ to 2 v. and is filled with a ternary eudectic mixture of sodium hydroxide, bromide, and iodide at 450 to 480° F. Molten sodium floats to the surface and is skimmed off periodically. The sodium metal contains ½ to 1% Hg and is purified by passing it over metallic calcium at 715° F. whereby the mercury content is reduced to 0.01%. Advantages of this process over the classical Down process (*10*) are: (a) lower operating temperature, (b) lower power consumption, (c) simultaneous higher production of chlorine, (d) less wear of graphite anodes, and (e) no steam or gas for salt evaporation and drying; on the other hand, the salt consumption is higher, metallic calcium, sodium bromide, iodide, and mercury are required.

Table 5.—Vertical Rotating Disc Cell

			Discs on Shaft	Discs on Drum
Dimensions	Cell:	length, ft.	10	9¼
		width, ft.	8	7
		height, ft.	6½	7¼
	Discs: (Cathode)	number of discs	4	5
		diam., ft.	6	6
		thickness, in.	¾	¾
		width of disc cavity, in.	1¼	1¼
		immersion of disc in Hg in.	39	25
		rev./min. of discs	6	7
	Drum:	diam., ft.	..	2
	Anodes:	number of anodes	8	6
		thickness, in.	3	3
		number of contacts to each anode	4	8
Electric Power		amp.	24,000	24,000
		v.	4.0-4.5	3.75-5.0
		efficiency %	92	92
		cathode dens. amp./sq.in.	1.55	1.11
Consumption/ton of Chlorine		power, kw-hr.	3,300	3,500
		NaCl, lb.	3,620	3,640
		graphite, lb.	10.2	10.3
		Hg, lb.	0.62	0.94
Hg/cell		lb.	3,750	2,860

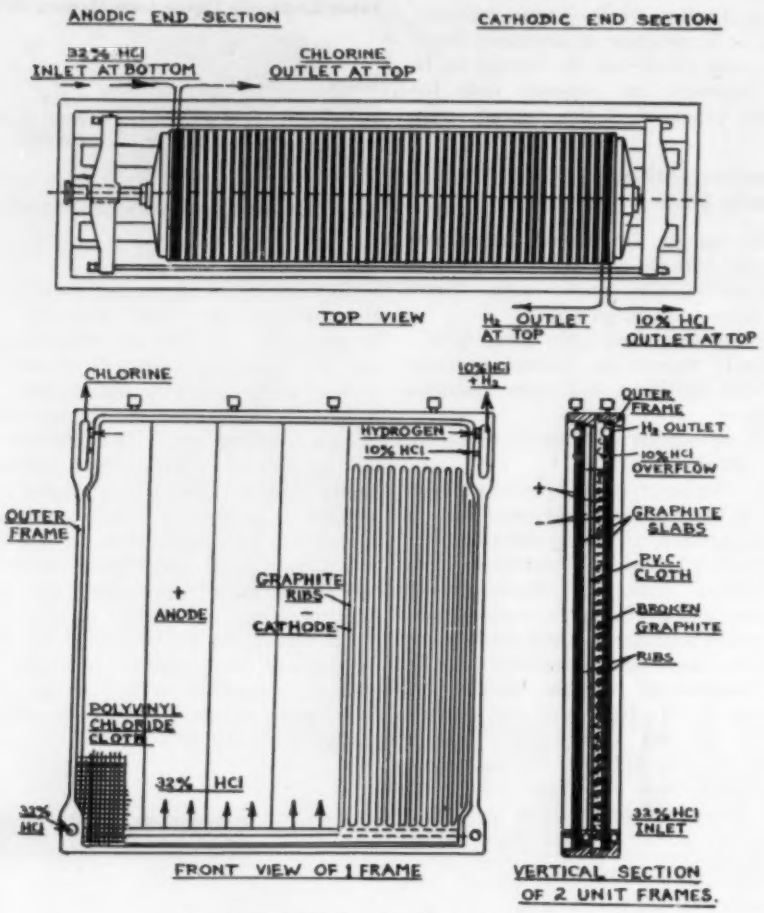

Fig. 10. Hydrochloric acid electrolysis

An arrangement of two rotating mercury disc cells in a series may be used not only for the production of sodium metal but also for the electrodeposition of other metals, such as zinc, lead, tin, cadmium, or manganese. With the use of the amalgam formation, these metals can be separated in high purity from low-grade ores or metal scrap (*16, 17, 30*).

(3) The third possibility of making chlorine without caustic is by using hydrochloric acid as a raw material which is obtainable as a by-product in the substitution chlorination of organic compounds. Here the hydrochloric acid is reconverted into chlorine by oxidation or electrolysis. A process for electrolyzing aqueous hydrochloric acid was developed at Bitterfeld and Wolfen (*9*). The electrolytic cell is designed in a series type, like a filter press, as illustrated in Figure 10. The cell operates at 2.3 v. and consists of thirty units. The electrodes are graphite slabs mounted in acid-resistant insulated frames. Diaphragms, made of PVC or Saran fabric, are placed between the electrodes to separate the chlorine from the hydrogen gas. Broken graphite lumps are held in front of the anodic side by the diaphragm and form the anode on which the chlorine is released. This arrangement in which the graphite can be used up completely is the first step towards a continual electrode. The power consumption is 1,800 kw.-hr./ton of chlorine produced (*32*).

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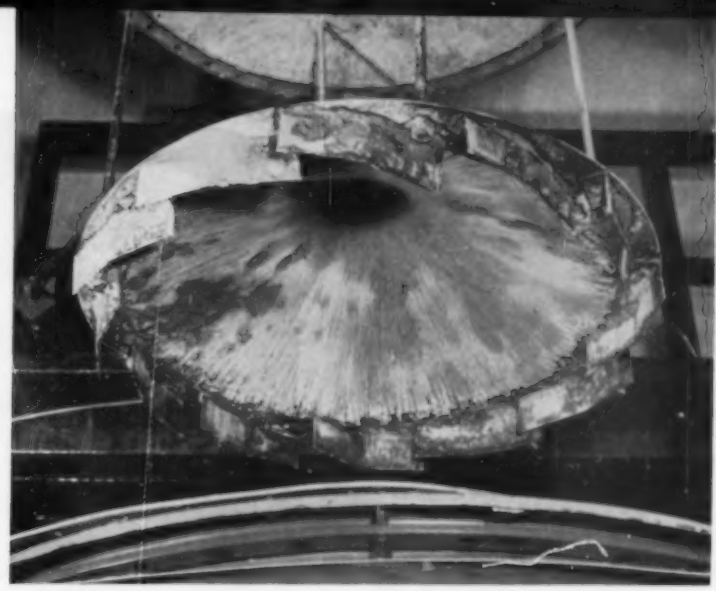

Fig. 5. Vapor dome baffle, vertical tube evaporator.

What studies in evaporative concentration of radioactive wastes have told us about

ENTRAINMENT IN EVAPORATORS

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Brookhaven National Laboratory, in the course of its activities, generates gaseous, solid, and liquid radioactive wastes which must be disposed of safely in the most economical way possible. Even before the construction of the B.N.L. nuclear reactor was underway, it was recognized that the concentration and safe disposal of considerable amounts of slightly contaminated liquid waste would constitute a problem. The solution of this problem provided the material for this paper.

Consideration of the variety of radioactive species expected in the waste streams convinced workers that no ordinary sewage treatment methods would suffice to remove all the radioactive elements anticipated. To handle all waste stream compositions, evaporation was chosen as the concentration process to be studied.

The background activity of Long Island water in the water table is in the order of 10^{-15} curies/ml. Dilute liquid waste resulting from the Laboratory's operation was expected to range in activity from 10^{-15} to 10^{-10} curies/ml.; the average still-pot activity concentration for design purposes was taken as 3×10^{-6} curies/ml. The Atomic Energy Commission set a level of 3×10^{-12} curies/ml. (a 90-day average) above which concentration liquid waste might not be released to the environment. Therefore, a process was required which would produce an over-all decontamination factor (still-pot activity/product activity) of at least 10^6, and preferably 10^7.

The problem of purification of a water vapor stream resulting from an evaporation step is a problem in deentrainment of vapor-borne particulate matter on the assumption that the impurities are nonvolatile in nature. The generation of entrainment was studied in two different types of evaporators; one, a horizontal submerged coil evaporator; two, a vertical tube natural circulation evaporator. The removal of entrainment from vapor streams was studied in three different types of devices: a bubble-cap column, a Raschig-ring-packed tower, and a Thermal Wool Fiber Fiberglas *-packed tower.

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Research work carried out under the auspices of the U. S. Atomic Energy Commission.

* Product of Owens-Corning Fiberglas Corporation.

Theory

The limits to radioactive decontamination of liquids by evaporation are determined by the carry-over of activity by entrainment, splashing, and foaming, and the carry-over of volatile radioactivity. In all of this work nonvolatile radioactive matter was used. The present work concerns (a) the generation of radioactive entrainment in evaporators, including a study of the control of splashing and foaming, and (b) the removal of radioactive entrainment from a vapor stream by vapor filtration.

(a) ENTRAINMENT GENERATION IN EVAPORATORS

The mechanism of liquid carry-over from boiling liquids in evaporators has been studied by Vorkauf (*6*), O'Connell and Pettyjohn (*3*), and by others (*1*). It is beyond the scope of this report to develop or validate the various theories which have been proposed, but a brief review follows.

Carry-over (*3*) can be caused by:

1. Entrainment of small liquid droplets by the moving vapor
2. Splashing of the violently boiling liquid directly into the vapor vent line
3. Foaming of the solution to the extent that foam is carried over into the vapor vent line.

In general, entrainment contributes less to carry-over contamination than does splashing or foaming. Entrainment results when liquid droplets, formed at the surface of the boiling liquid or formed by bubble breakage, are thrown into the vapor space above the boiling liquid and are carried by the vapor stream if their rate of fall is less than the vapor velocity. O'Con-

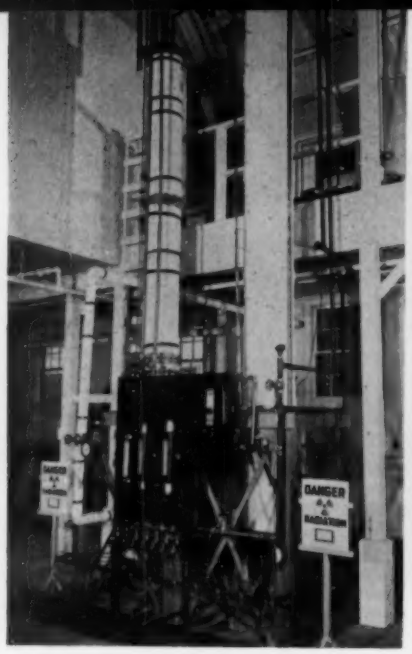

Fig. 1. Submerged coil evaporator unit.

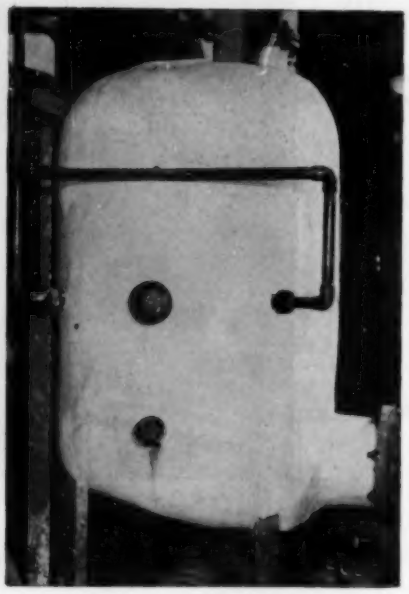

Fig. 2. Close view of submerged coil evaporator.

nell and Pettyjohn (*3*) noted that entrainment concentration in the overhead decreases with increase in heat flux density at constant boiling point up to a certain heat flux density, but that continued increase in the heat flux density caused the solution to boil so violently that liquid is splashed overhead. Both the entrainment rate and the vaporization rate increase as the heat flux density increases. However, at low vaporization rates the entrainment rate increases less rapidly than the vaporization rate, so that the concentration of entrainment in the vapor decreases. The authors just referred to concluded that in a given evaporator there will be an optimum heat flux density to give a minimum carry-over. It will be shown in a later section that this minimum in carry-over was also observed in the present work. By proper evaporator design splashing can be largely eliminated; foam carry-over however is quite unpredictable. The specific solution to be evaporated must be examined for foaming tendencies in each case. Foaming can be controlled usually by one or more methods, such as dilution, use of a water spray, use of antifoam agents, reduction of the boil-up rate, or installation of a steam coil foam breaker in the vapor space. Even moderate foaming, such as is always encountered in the evaporation of dilute radioactive waste, leads to relatively high entrainment carry-over, probably by the mechanism of bubble breakage.

Whatever mechanism projects liquid droplets into the vapor space may also project any suspended solids present. Although suspended solids, such as rust, normally are not considered noxious contaminants, in this case they are likely to have adsorbed considerable amounts of radioactivity, and if carried over into the condensate, will impart radioactive contamination to the condensate by subsequent desorption.

Liquid droplets or foam bubbles containing steam thrown into the vapor space have an initial size distribution. This distribution may be considerably altered by conditions in the vapor space, *e.g.*, droplets may evaporate until the droplet surface tension forces are equalized by the vapor pressure. The size distribution of suspended solids depends primarily on the size distribution in which they are initially present in the solution.

All particulate matter in the vapor space above the boiling liquid may be considered to belong to one of three groups:

1. Particles whose rate of fall is so small that they are carried out of the evaporator by the vapor stream.

2. Particles whose rate of fall is roughly equivalent to the vapor velocity in the evaporator vapor space. It would be expected that particles in this size range would build up to some equilibrium concentration within the vapor space of the evaporator.

3. Particles whose rate of fall is greater than the vapor velocity. These particles will fall back into the boiling liquid if sufficient vapor space is provided within the evaporator for them to reach the end of their trajectory or if a suitable baffle is so placed as to deflect the particles back down into the boiling liquid. It is understood that, if these particles reach a path of sufficiently high velocity, they may leave the evaporator (splashing). It is readily apparent, then, that even when foaming and splashing conditions are kept under control, the vapor stream leaving any evaporator can and does carry along foam bubbles and entrained liquid and solid particulate matter, and that the concentration, amount, and particle-size distribution of such carry-over will vary from evaporator to evaporator and will depend upon the specific liquid being evaporated.

(b) DEENTRAINMENT FROM THE VAPOR STREAM

The mechanisms by which entrained particulate matter is removed from a vapor stream have been discussed by Rodebush *et al.* (*4, 5*) and by Langmuir and Blodgett (*2*). They are direct interception, gravity, inertia, diffusion, and electrostatic forces. In general, the entrainment removal efficiency of devices depending upon impaction and inertial effects, such as cyclones, bubble-cap or Raschig-ring columns, will be good for average particle diameters 100μ or more, but poor for particles of 10μ or less in diameter. To remove submicron particles efficiently from vapor streams, filtering media such as Fiberglas or fine-pore filter paper have been used. Here the removal mechanism is predominantly one of diffusion, although for some filter material electrostatic forces may play an important part (*4*).

In general, if particulate matter is in the size and density range where it can be removed by inertial effects, one can expect to find an increase in filtering efficiency with an increase in vapor velocity. On the other hand, a decrease in filtering efficiency with an increase in vapor velocity usually indicates that diffusion is the primary mechanism of particle removal. Increasing the vapor velocity would have little effect on the filtering efficiency due to direct interception.

Experimental Equipment

From the extensive literature on nonradioactive entrainment in evaporation and distillation columns, it was recognized at the outset that a single evaporation stage would probably not achieve the decontamination desired. Therefore, the experimental program consisted of the measurement of radioactive entrainment encountered in treating radioactive feed solutions in (a) a double distilla-

tion system; (b) a single effect submerged-coil evaporator followed by deentrainment units; and (c) a short-tube vertical natural circulation evaporator followed by a deentrainment unit.

Acceptable over-all decontamination factors were achieved with a double distillation system (two successive distillations). Forced circulation, long-tube natural circulation, and other types of evaporators were not studied, based on the belief that evaporation in the simplest and most economical manner followed by efficient deentrainment would result in the most economical and yet completely effective system for handling dilute liquid wastes containing heterogeneous radioactive material. The economic aspect ruled out further development of the double distillation system.*

A photograph of the single-effect, submerged coil evaporator, deentrainment columns, sampling taps, and instrument panel board is shown in Figure 1; a closeup of the submerged coil evaporator is shown in Figure 2; and a diagrammatic flow chart for the above-mentioned equipment is depicted in Figure 3. The vertical tube evaporator with its deentrainment unit is shown as components in a vapor compression evaporator system in Figure 4.

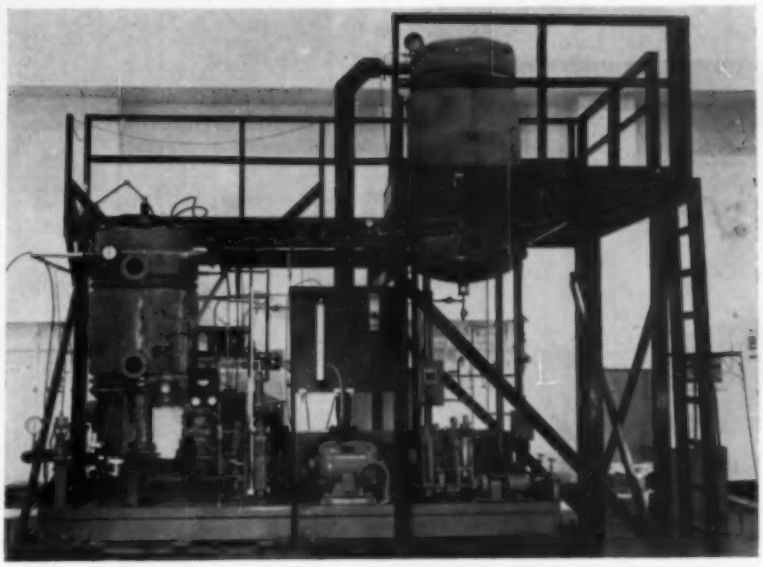

Fig. 4. Vertical tube, vapor compression evaporator unit.

1. SUBMERGED COIL EVAPORATOR SYSTEM

a. Evaporator

In Figure 3 the steam supply to the submerged coil evaporator and cooling water for the condensers are not shown. The vapor generated by the liquid boiling in the evaporator passes through the superheater (shown in Sketch B), and then through either (a) a 13-plate bubble-cap column, or (b) a 9-ft. column packed with either ½-in. Raschig rings, or Fiberglas of 14-20μ fiber diameter. From the columns the vapor is condensed and the liquid returned to the evaporator. The packed column is electrically heated and thus can be operated to permit or prevent condensation within. When vapor is allowed to condense within the tower, the liquid is returned to the evaporator through the 1-in. line shown. The superheater was not always used. It provided a means of studying the efficiency of filtration of solid particles by the vaporization of liquid particles.

The submerged coil evaporator is constructed of steel and is cylindrical in shape, approximately 29 in. in diam. by 50 in. high. The steam heater consists of a coil of 1½-in. copper tubing with a total surface area of approximately 6 sq.ft., which is located approximately 9 in. below the average liquid level.

* Discussion of this piece of equipment will be omitted in this paper.

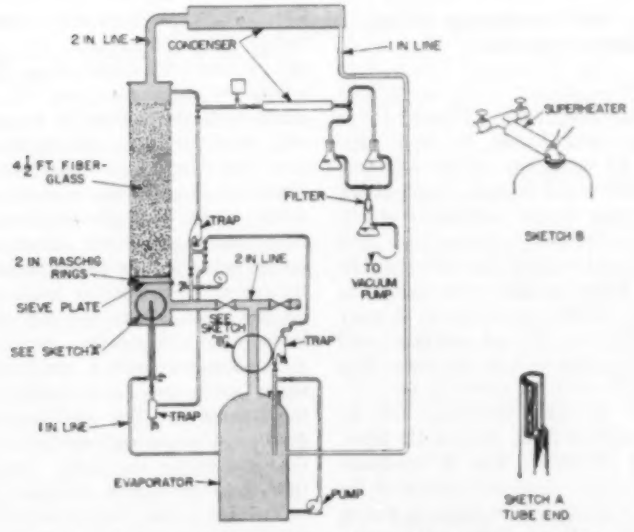

Fig. 3. Diagrammatic flow chart, submerged coil evaporator unit.

b. Deentrainment Units

The packed tower is constructed of three sections of 10-in. standard steel pipe with standard flanged joints. The perforated plate containing 139 ⅛-in. holes used as the packing support rests on the top of the bottom 16-in. section. A 1-in. line drains the liquid from the bottom back to the still pot, and the vapor enters through a 2-in. line on the side. The second section, 5 ft. long, contains a 4-in. blanked flange near the bottom through which the packing may be removed. The top section, also 5 ft. long, has a special distributor at the top. The reflux enters through a ¾-in. line, and the vapor leaves through a 2-in. line. Both connections are made through the top flange.

The tower is packed with ½-in. Stoneware Raschig rings to a height of about 8 ft. 10 in., the top of the packing being about 11 in. below the distributor plate.

In order to allow for the small reflux ratios planned, a special distributor was designed. This distributor consists of a cup whose outside diameter is very nearly the same as the inside diameter of the column. Through the bottom eight 1½-in. pipe chimneys were welded. These pipe chimneys extended 1½ in. above the bottom of the cup, and the top of the chim-

Fig. 6. Fiberglas-packed vapor filter cartridge, vertical tube evaporator.

Fig. 8. Vapor filter unit, vertical tube evaporator.

Fig. 7. Improved vapor filter cartridge, vertical tube evaporator.

neys was leveled. Four V-shaped weirs were cut in each pipe chimney to a depth of ½ in. The reflux entering the plate through a ¾-in. pipe fills the plate up to these overflow weirs and then flows down the pipe chimneys on to the packing.

The same tower was used to contain TWF Fiberglas packing. The sieve plate used as a packing support rests on the top of the bottom 16-in. section. Two inches of ½-in. porcelain Raschig rings provided further support for the 4½ ft. of TWF Fiberglas packing. The Fiberglas was packed to a density of 5 lb./cu.ft.

The bubble-cap column is 14 in. in diam., containing 13 plates with 11¾-in. plate spacing. Each tray contains ten 2-in. bubble caps. Material of construction is copper throughout. The 2-in. vapor inlet line is located just below the first plate and about 9 in. above the bottom of the tower. Liquid can drain back into the still pot through a 1-in. line. The vapor from the top of the column to the condenser leaves through a 2-in. line, and the reflux returns to the top plate in a 1-in. line.

The condenser for the unit is constructed of steel with the water flowing through the tubes. The vapor is condensed on the shell side. The capacity of this condenser is more than ample to condense the water vapor at the highest vapor velocities used for the test unit.

2. VERTICAL TUBE EVAPORATOR SYSTEM (VAPOR COMPRESSION STILL)

a. Evaporator

The evaporator body (Figure 4) is 6.2 ft. high and 2.5 ft. in diam., and reduces to 1.8 ft. in diam. at the calandria section, which is 2.3 ft. high. Each of the four removable flanged sections is of all-welded Everdur 1010 construction. The evaporating section is of the shell-and-tube type, with tubes arranged vertically. The thick liquor (operating volume = 16 gal.) is contained in the still pot and tubes, and the vapor is condensed in the shell. The evaporator contains 411 tubes, ¾ in. O.D., with 0.049 in. wall thickness, and an effective length of 22 in. Of the 411 tubes, 402 are of Admiralty type B condenser tubing. The vent condenser section of the evaporator consists of nine tubes of cupronickel 70-30. All the feed water enters the evaporator by first passing through the vent condenser tubes, around which the last bit of uncondensed vapor in the shell side passes. The total evaporator surface is 148 sq.ft. based on the outside diameter of the tube.

Since the evaporator is used in a vapor compression cycle, auxiliary heat is necessary for starting and making up heat losses. Auxiliary and starting heat is supplied by steam condensing in a copper coil, 50 ft. long, ⅝ in. O.D., and 0.035 in. wall, located under the lower tube sheet in the still pot. The heating surface is 8.2 sq.ft., based on the outside diameter of the tube.

b. Operation

Feed stored in the 100-gal. feed tank flows to the feed pump, feed rotameter, solenoid valve (controlled by the still head temperature), through the heat exchanger, and into the evaporator still pot. The still-pot contents boil inside the tubes of the calandria, liberating water vapor, liquid and solid entrainment, foam bubbles, and splashed liquid into the vapor space above the calandria.

The vapor encounters a vapor dome (Figure 5) mounted just above the upper tube sheet. Partial separation of liquid and vapor is achieved in this device by the centrifugal action of the liquid leaving the vapor dome through louvres placed tangentially around the periphery.

A certain amount of settling of the larger particles takes place in the vapor space above the tube bundle before the vapor leaves the still head and flows in a 4-in. duct to the inlet end of the vapor filter. The vapor is passed through a deep bed of TWF Fiberglas in the vapor filter unit. About 1.5% condensation takes place within the vapor filter and this reflux is collected in the bottom of the filter unit and drained back to the evaporator still pot. The filtered vapor then passes to the Roots-Connorsville steam compressor and finally to the shell side of the evaporator tube bundle where the steam condenses on the tubes, giving up its latent heat to the still-pot liquid boiling inside the tubes. At the point where the hot condensate leaves the evaporator, noncondensable gases, together with a small amount of steam vapor, are continuously vented to the atmosphere. The condensed vapor or distillate flows through the heat exchanger, thus preheating the feed. The distillate then flows through a rotameter and may be rejected to the drain or recycled to the feed tank.

3. SAMPLING

For the submerged coil evaporator, a product sample is taken from the return line from the condenser to the evaporator and vapor samples are taken from the still pot, the vapor space just before and just after the filter, and from the 2-in. line connecting the evaporator and packed tower. In the sampling procedure the vacuum pump is started, the valves are opened for the sample to be taken, and enough vapor is drawn to warm up and clean the lines. The "warm-up" condensate is drained from the traps and the sample drawn at a controlled rate for timed interval. The sample condensate traps are so designed that there are no sharp bends between the point being sampled and the first trap in the sample line, in order to retain large particulates within the sampling system. Each vapor sample contains three components: the main bulk of the condensed vapor, the condensed vapor in the line between the sample condenser and the common trap, and the condensed vapor in the line between the common trap and the trap nearest the sample point. The noncondensables from each sample are drawn through a filter disk of paper* to catch any fine particles that may be in the vapor stream.

An evaporator liquid sample is taken by recirculating the still-pot contents and bleeding off a sample just after the pump. This sample is taken last. Results of specific experiments indicate that there is no significant contamination by this recirculation technique.

Liquid samples are also taken of the condensate returning from the tower and of the condensed liquid in the line connecting the tower and the evaporator. Similar samples were taken in the vapor compression equipment.

Results

A. SUBMERGED COIL EVAPORATOR SYSTEM

1. Decontamination Efficiency of a Submerged Coil Evaporator

An attempt was made to evaluate both the internal performance of the evaporator with regard to entrainment, *i.e.*, the efficiency of deentrainment, using only a vapor space and the performance of the evaporator as a unit, including an interconnecting line to the next piece of equipment.

In order properly to evaluate evaporator performance, consideration first was given to the difference in effects of entrained liquid droplets and entrained solid particles. In this experiment the solid particles arise from suspended solids found in the still-pot solution, consisting mainly of rust formed by the corrosion of the mild steel evaporator. These rust particles, in general, are quite small, as evidenced by samples of still-pot solution remaining turbid after several days of settling.

Since mixed fission products adsorbed strongly on the rust particles, whereas P^{32} activity did not, it was possible to distinguish between entrained solids carry-over and liquid entrainment by a radiochemical analysis.

Typical results of the effect of boil-up rate on the decontamination factor for liquid entrainment are shown in Figure 9. Curves AB and A'B refer to decontamination factors calculated from data obtained by direct vapor sampling in the evaporator. Curve CD refers to decontamination factors calculated from tower reflux data. These latter data should indicate the behavior of the evaporator plus the vapor discharge line, which performance should better the behavior of the evaporator alone because of the factor of partial return of impacted entrainment to the vapor space. In all a series of nine curves was obtained. Typical of complex systems in which a large number of variables exist, the data obtained scattered appreciably, but the same general trend as in Figure 9 was obvious. Each curve, taken separately, shows a transition from an initially increasing decontamination factor to a decreasing decontamination factor as the boil-up rate is increased. All the curves could be described by an equation of the form:

$$D.F. = KG^{\pm n}$$

where

$D.F.$ = decontamination factor
G = boil-up rate, lb./(hr.)/(sq.ft. of disengaging area)

and K and n are constants for any given set of condition. The sign of n will indicate whether the equation is describing the increasing or decreasing portion of the curve, and $D.F.$ may be defined by:

$$D.F.\ \text{evaporator} = \frac{\text{still-pot activity/ml.}}{\text{evaporator vapor activity/ml. (condensed)}}$$

$$D.F.\ \text{evaporator plus line} = \frac{\text{still-pot activity/ml.}}{\text{reflux activity/ml.} \times \text{reflux ratio}}$$

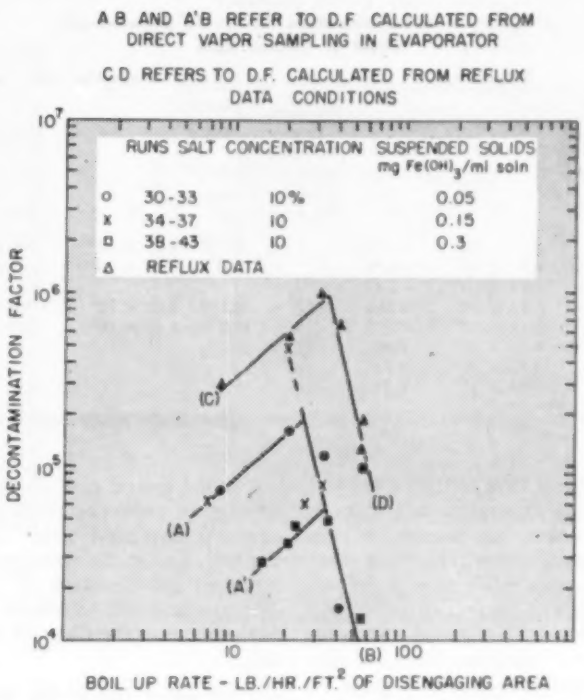

Fig. 9. Effect of boil-up rate on the decontamination factor for liquid entrainment-submerged coil evaporator.

* A. D. Little (Filter Paper).

Table 1.—Decontamination for Liquid Entrainment Effect of Boil-up Rate

Evaporator					Evaporator plus line			
Salt Conc. (%)	Suspended Solids milligrams $Fe(OH)_3$ ml. soln.	K	n	Transition Point (lb.)/(hr.) (sq.ft. of disengaging area)	Salt Conc. (%)	K	n	Transition Point (lb.)/(hr.) (sq.ft. of disengaging area)
0.1		6.7×10^{10}	−3.75		0.1	2.8×10^{12}	−4.45	
0.1		4.5×10^{10}	−4.75		0.0	1.54×10^{12}	−4.0	
10.0		1.04×10^{10}	−3.47					
0.1	0.02	7.8×10^{4}	0.666	22	0.1	2.1×10^{4}	0.69	23
0.1	0.04	2.35×10^{4}	0.732	28	10.0	5.4×10^{4}	0.81	35
0.1	0.04	8.1×10^{3}	0.60	28				
10.0	0.3	3.93×10^{5}	0.74	24				
10.0	0.1	1.31×10^{4}	0.81	34				

The significant item in the curves and in Table 1 which summarizes them is the approximate agreement in the slopes, n. The K's vary from each other mainly because of differences in the salt concentration and suspended solids and because of known differences in analysis. For design purposes the most conservative values of K and n given in Table 1 were taken, and the assumption was made that the evaporator deentrainment behavior was independent of still-pot solution salt concentration. It is recognized that this assumption probably is incorrect, but it is felt that the value of a simple applicable approach to a complex phenomena justifies deemphasizing variables of relatively little significance. It is suggested, therefore, that the following equation should be applicable to a simple submerged coil evaporator with no restrictions between the vapor space and condenser that could remove entrainment by inertial effects. These equations would be expected to hold for free board conditions approximately the same as those in this experiment.

$$D.F. = 4 \times 10^{8} G^{0.75} \quad \text{(low boil-up rates to splash point)} \qquad (1)$$

$$D.F. = 1 \times 10^{10} G^{-3.5} \quad \text{(above splash point)} \qquad (2)$$

For the case of an evaporator with a restriction or baffle, the K's in the above equations would be higher, and the exponents would remain about the same.

Foaming would alter the values of K and would alter the splash point. If the foam is such that all bubbles break at the surface, Equation (1) should hold up to the splash point, except that the K should be much lower. If hollow foam bubbles are readily carried into the vapor space, the splash point should occur at lower boil-up rates than occur in the same equipment without foaming.

The splash point should be a function of the height of the vapor space. This variable was not studied in detail.

For the special case of evaporating a solution of radio-chemicals in the presence of suspended solids upon which the activities in the solution are readily adsorbed and desorbed (in general, fission products will behave this way), the following equations should be of interest.

$$D.F. = 42G^{0.9} \quad \text{(up to the splash point)} \qquad (3)$$

$$D.F. = 2.9 \times 10^{5} G^{-1.3} \quad \text{(beyond the splash point)} \qquad (4)$$

It should be noted that these decontamination factors are appreciably lower than those for liquid entrainment. The decontamination factors alone are defined as the ratio of fission product activity/ml. in the still pot to the fission product activity in the condensed vapor/ml. The above equations apply simultaneously with Equations (1) and (2) but only to that portion of the activity which is strongly adsorbed on the suspended solids.

2. Decontamination Efficiencies of Three Deentrainment Devices

Data obtained on the individual deentrainment devices were not sufficiently reliable to make a valid direct performance comparison. However, it is believed that the over-all efficiency of the system (*i.e.*, evaporator plus deentrainment device) is a significantly comparable factor.

As Table 2 indicates, a column filled with Fiberglas made the entire system far more efficient than the inclusion of either a bubble-cap column or a Raschig-ring-packed tower.

Calculations indicate that the bubble caps are efficient only for removal of particulates greater than about 15μ in diam., and Raschig-ring packing should be inefficient for removal of particulates smaller than about 50μ in diam. The behavior of the three deentrainment devices clearly indicates that the carried-over material in this part of the system is an aerosol.

B. VERTICAL TUBE, VAPOR COMPRESSION EVAPORATOR SYSTEM

1. Decontamination Efficiency of a Vertical Tube, Vapor Compression Evaporator

The nature of the feed and the characteristics of this evaporator were such that the still-pot liquid foamed in almost every run. The most consistent results were those for the evaporator plus the vapor discharge line, *i.e.*, the *D.F.*'s based on tower reflux data. Since the evaporator was foaming, all the data are considered to be beyond the splash point. Figure 10 indicates the results of forty-two runs. This plot is not intended to show a correlation but merely to show that a design based on the performance of a submerged coil evaporator is conservative. Superimposed on the plot is the straight line found for the submerged coil evaporator plus its vapor discharge line. The majority of the data show a higher decontamination factor for a given boil-up rate than obtained with a submerged coil curve. These differences are probably due to the inherent differences between the mechanism of entrainment formation for a submerged coil and a vertical tube evaporator, but it is perhaps significant that the submerged coil plot is a conservative estimate of the performance of the vertical tube evaporator.

2. Decontamination Efficiency of a Fiberglas Vapor Filter

Much data were obtained on the performance of the deep Fiberglas filter in the vapor compression system. The most consistent results were those based on the vapor filter reflux activity level. An activity balance taken on the vapor filter unit for low reflux ratios permits the following definition of the filter decontamination factor.

$$DF_f = \frac{X_i}{X_D} = \frac{D}{V} + \frac{R}{V}\frac{X_R}{X_D}$$

where

DF_f = filter decontamination factor

Table 2.—Three Deentrainment Devices Relative Efficiencies

System: Fission product solution, boil-up rates of approximately 10-65 lb./(hr.)(sq.ft.)

Deentrainment Device	Average Over-all Decontamination Factor (still-pot concentration/overhead concentration)
8.8 ft., ½-in. Raschig rings	9×10^{5}
13 plates, 2-in. bubble caps	6×10^{6}
4.5 ft., 20 μ Fiberglas	4×10^{7}

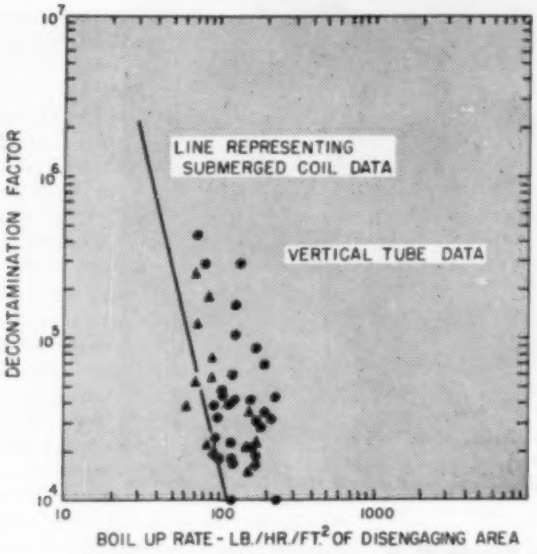
LINE REPRESENTING SUBMERGED COIL DATA
VERTICAL TUBE DATA
DECONTAMINATION FACTOR
BOIL UP RATE - LB./HR./FT.² OF DISENGAGING AREA

Fig. 10. Decontamination factor vs. boil-up rate, vertical tube evaporator.

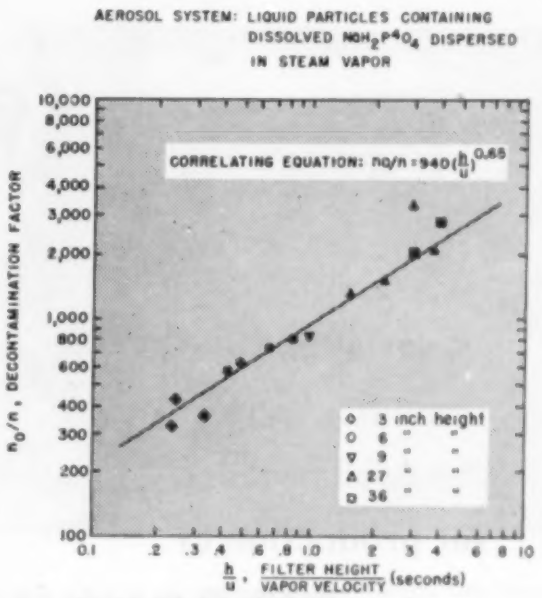
AEROSOL SYSTEM: LIQUID PARTICLES CONTAINING DISSOLVED NaH₂P⁴O₄ DISPERSED IN STEAM VAPOR
CORRELATING EQUATION: n₀/n = 940(h/u)^0.65
n₀/n, DECONTAMINATION FACTOR
3 inch height
6 " "
9 " "
27 " "
36 " "
h/u, FILTER HEIGHT / VAPOR VELOCITY (seconds)

Fig. 11. Decontamination factor vs. retention time for unbonded 20μ diam. Fiberglas, vertical tube evaporator.

X_i = activity concentration of condensed vapor to filter (counts/ml.)

X_D = activity concentration of condensed vapor leaving filter (counts/ml.)

X_R = activity concentration of reflux liquid (counts/ml.)

D = vapor leaving filter (lb./hr.)

V = vapor entering filter (lb./hr.)

R = liquid reflux leaving filter (lb./hr.)

Figure 11, in which filter decontamination factor is plotted against holdup time in the filter, indicates the results. There is good correlation with an equation of the form

$$DF_f = A\,\frac{(h)^b}{(u)} \qquad (5)$$

where

h = filter height (ft.)

u = vapor velocity (ft./sec.)

This correlation is similar to one proposed by Rodebush *et al.* (*4*) in a paper dealing with filter penetration by aerosols. It shows that the mechanism of aerosol removal is diffusion rather than impaction because filter decontamination factor decreases with increasing vapor velocity.

In evaporative systems where the decontamination factor is measured from reflux data as above, the constant A would depend upon the efficiency of the rough deentrainment devices, such as baffles, the vapor discharge line, or the plenum chamber previous to the filter, for knocking down large particles. The exponent b should be a measure of the efficiency of the filter for the removal of fines, and should be a function of the concentration and particle-size distribution of the aerosol in the vapor stream.

Results—*Summary*

It was found that both evaporators studied generated about the same amount of entrainment at comparable boil-up rates, resulting in evaporator decontamination factors of about 10^4 to 10^5. The evaporator decontamination factor is defined as the ratio of the activity/ml. of the still-pot solution to the activity/ml. of condensed vapor leaving the evaporator. It should be noted, however, that excessive foaming or splashing in the evaporator can result in much lower decontamination factors. Bubble-cap and Raschig-ring-packed columns were found to be less effective in removing submicron radioactive particles than Fiberglas-packed columns which proved to be the best entrainment removal devices. Metallic wool packings are currently under study, and show some promise in this application. For evaporation economy, a vapor compression unit coupled with a Fiberglas vapor filter was studied on a semiworks scale (50-80 gal./hr.). Since this system proved satisfactory on both a technical and economic basis, a similar system of 300 gal./hr. capacity was designed and erected at Brookhaven National Laboratory to handle the full-scale liquid waste streams. This evaporator, representing the results of five years of research and development, was put into operation in the summer of 1953. Over-all decontamination factors of 10^6 or greater are regularly being achieved.

evaporation

Acknowledgment

The authors acknowledge the help and suggestions of R. W. Southworth and T. Van Winkle.

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Presented at A.I.Ch.E. meeting, Washington, D. C.

Fig. 8. Reduction mass of zirconium in tray from which magnesium chloride escaped through drain holes.

variations and modifications of the Kroll process for production of

ZIRCONIUM METAL

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U. S. Bureau of Mines, Albany, Oregon

The Kroll process, as employed today in the production of zirconium and titanium metal, is essentially a multistep batch process (*1*). Considerable effort and large sums of money are being applied to the problem of making the process continuous, without any great success, although several patents have been issued in the field (*2, 3*).

Development work has continued at the Bureau of Mines zirconium production plant at Albany, Oregon, in an effort to streamline production methods making the existing furnaces and facilities more effective without additional expenditure for primary equipment. As a result of many small improvements, the plant capacity has been doubled, and it is felt that the techniques leading up to and eventually effecting the increase might well be described.

Reduction Studies

The initial improvement effort was launched on the reduction step, and as the nature of the reduction and the physical activity within the reduction pot were not entirely understood, several test runs were made to clarify the matter. Observation of a pot during various phases of reaction through quartz windows in the furnace lid was informative. It was demonstrated clearly that initiation of the reaction between molten magnesium and zirconium tetrachloride was not accomplished readily at the usual operating temperature of 825° C. When the reaction did start, it appeared as a thin line of fire at the interface of the molten magnesium surface and the wall of the iron reduction pot. At no time did the reaction spread to the surface of the molten magnesium and, occasionally, only half of the periphery was active. Reaction at the wall limits the rate because zirconium and iron react to form a 16% iron eutectic at a temperature of about 935° C. Since the observed temperature of the reaction "line" was 1,000 to 1,100° C., it is obvious that only the heat conduction through the iron pot and bath of magnesium and magnesium chloride can dissipate the energy released by the reaction and prevent serious iron contamination of the zirconium. Another feature helping to repress iron reaction was the continuous rise of the magnesium chloride level which tended to quench any overly active areas of reaction.

Further insight into the nature of the reduction reaction was gained by taking a regular run only one third of the way to completion, and then by stopping the reaction as rapidly as possible. The entire reduction pot was sawed in half vertically, and the distribution of products examined. A rather interesting situation was found to exist as depicted in Figures 1, 2, and 3. Figure 1 shows the pot just as sectioned; figure 2 indi-

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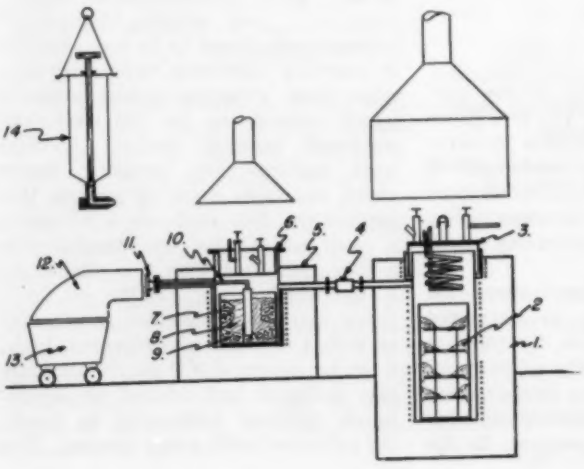

Fig. 5.
1. purification furnace;
2. zirconium chloride container;
3. floating top;
4. plug valve;
5. reduction furnace;
6. bolted top;
7. reduction crucible;
8. magnesium chloride;
9. zirconium metal;
10. eduction tube;
11. drive valve;
12. salt deflector;
13. salt receiver;
14. magnesium ladle.

cates the metal distribution and shows the actual build-up of zirconium as evidenced by etching; figure 3 illustrates the results of the sampling and analyzing chemically of the metal slice shown in Figure 2. Several subsequent developments have shown that the travel of zirconium and magnesium, whether by gravity or thermal convection, or both, actually takes place, and constructions which defeat this movement materially affect the behavior of the reaction.

The presence in the pot (Figure 3, positions 4, 5, and 6) of a semifluid zirconium-magnesium "mud," led to speculation on collection and filtration work. Specimens of the mud were examined by placing them in a graphite funnel having 45° walls and 1-in. central opening. When the funnel was heated under helium to 800° C., that portion of the mud directly over the central opening in the funnel fell through. The remaining material adhered to the graphite wall and lost magnesium through drainage. The original sample analyzed 45.6% Zr and the drained material contained 70.9% and the drainings 12.8% Zr.

Pressure filtration through a perforated steel plate filter did not give results in proportion to the filter openings which led to the belief that the graphite funnel test was more of a sintering than a filtration test. Acid dissolution of the mass and measurement of individual particles of zirconium vindicated this assumption since the average dimension of the nondescript zirconium particles was found to be about 6μ. It should be noted that this material was of an extremely reactive and dangerous nature during leaching and drying.

Manipulation tests with the zirconium-magnesium mud showed that it changed nature by a sintering or coalescing action which ejected magnesium from the mass. If it were poked, scraped, or squeezed, it immediately lost its fluidity and adhered strongly to all materials of construction. The problem of scraping it from a plate or conveyor was complicated by the requirement of a second scraper to clean the first scraper and the resultant formation of a zirconium deposit which could not be scraped off. After accumulation of these more metallic forms of zirconium on the manipulators, galling and seizing soon immobilized all parts. The movement of magnesium-zirconium mud under any of the conditions tested was found to be impractical.

From the difficulties encountered in handling the zirconium metal in process, it appeared wise to concentrate simply on producing more of it in each pot. Since the regular operation filled the furnace to capacity, a considerable reduction in volume of some part of the usual charge was necessary if any great increase in production was to be effected. Zirconium chloride was the obvious point for this attack.

Zirconium Chloride Studies

Crude zirconium chloride may come from the chlorination operation (*4*) in several forms over which the chlorinator operators have limited control.

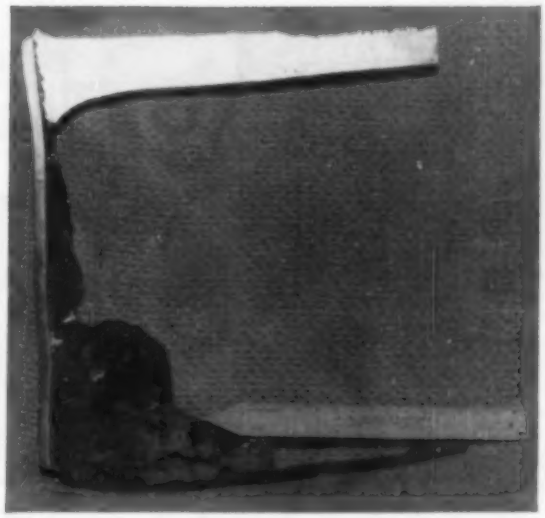

Fig. 2. Etched slice from face of section shown in Fig. 1. Metal strip at left is crucible wall.

Least desirable form is a light, fluffy material resembling snow and weighing as little as 15 lb./cu.ft. This is encountered often in a cold chlorinator condenser or when traces of moisture are present during the condensation of zirconium chloride from vapor to solid. This material presents a problem because of the poor loading factor and the presence of nonvolatile zirconium oxide, usually in concentrations as high as 25%. Under proper conditions of chlorination the chloride may appear in a dense, granular form described as "hail," in comparison with the previously described "snow." This form may appear also as a dense cake, sometimes an inch thick, which is prized highly by reduction operators because of its density (up to 68 lb./cu.ft.)

minerals processing

Fig. 1. Sectioned reduction crucible showing distribution of materials. Large striae show the crystal form of magnesium chloride.

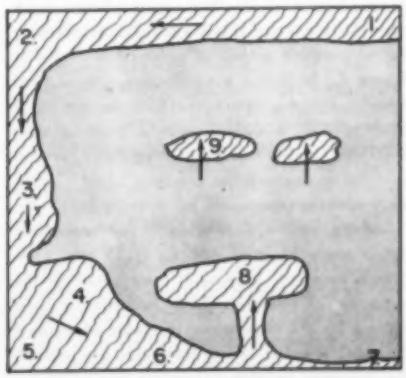

Fig. 3. Chemical analysis of metal shown in Figs. 1 & 2. Arrows indicate direction of metal movement.

% Zr	% Zr	% Zr
1. 1.35	4. 42.1	7. 40.6
2. 1.33	5. 57.0	8. 4.0
3. 45.6	6. 63.9	9. 4.0

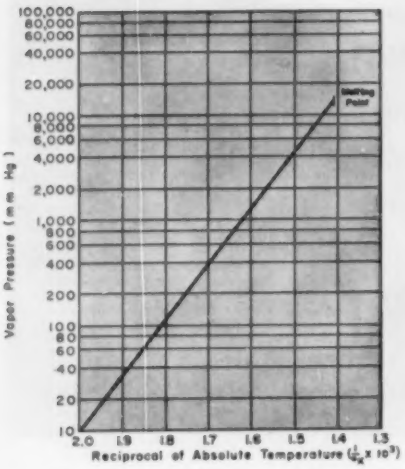

Fig. 4. Vapor pressure of $ZrCl_4$ (5).

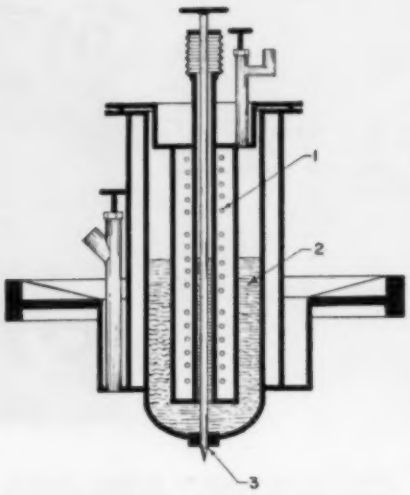

Fig. 6. Integral magnesium holding furnace: 1. heating elements; 2. molten magnesium; 3. addition valve.

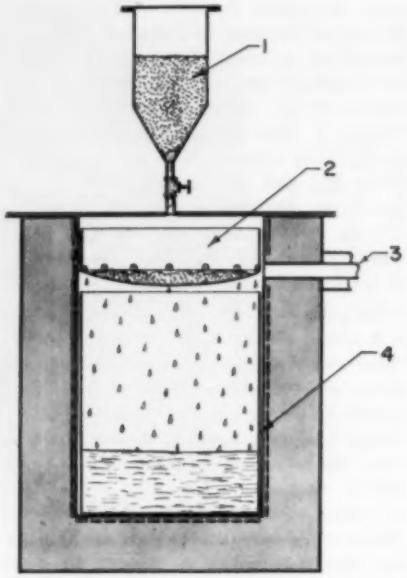

Fig. 7. Gravity drainage of magnesium chloride from the reduction crucible: 1. atomized magnesium; 2. perforated crucible; 3. connection to $ZrCl_4$ source; 4. magnesium chloride receiver.

and its low nonvolatile residue content (seldom in excess of 5%).

The above-mentioned forms of zirconium chloride may be purified and densified by sublimation to a product weighing 138 lb./cu.ft. with only 1% nonvolatile residue. Whereas this is the most desirable form of chloride, it was found that under production conditions the rate of production in the standard pit furnaces employed at Albany was about 20 lb./hr. which made the technique undesirable from an economic standpoint.

To raise the permissible rate of transfer during sublimation, pressure was applied by simply bolting the furnace shut. Initial tests showed that reliable pressure measurement within this equipment was most difficult because of condensation of solid zirconium chloride in or on the sensing elements. The pressure-temperature curve for zirconium chloride is quite unfavorable for temperature control of pressure as shown in Figure 4. To assure a satisfactory rate of heat transfer into the retort, the furnaces are operated at 500 to 600° C. and it may be seen from the curve that any irregularity in the sublimation-condensation cycle could cause destructive pressures.

Melting zirconium chloride is not impossible, but a temperature of 437° C. at 25 atm. pressure is required. Melting is complicated by the presence of moisture and hydrochloric acid formed by the breakdown of traces of zirconyl chloride. If traces of iron trichloride are present, the following reaction appears to take place:

$$2FeCl_3 \rightleftharpoons Fe_2Cl_6$$

$$Fe_2Cl_6 \rightleftharpoons 2FeCl_2 + Cl_2$$

The presence of chlorine makes the use of rupture diaphragms difficult and contributes to general attack on the equipment.

Fine quality cakes of zirconium chloride having a density of 155 lb./cu.ft. have been produced quickly by liquefaction, but practical application is inhibited by the problem of corrosion and the design of large-scale equipment for operation at the temperature and pressure required. It is likely that somewhere between the two operations of sublimation and liquefaction lie conditions under which moderately rapid transfer of chloride to a dense form may be effected without the rigorous conditions required for liquefaction.

Densification by compaction is a potential approach. It is possible to raise the density of chloride to a more or less uniform level of 150 lb./cu.ft. by applying a pressure of about 10 tons/sq.in. in an automatic briquet press, but corrosion problems are prohibitive for a machine requiring highly polished surfaces for successful operation. Compression at this pressure causes traces of moisture present in the chloride to react with the result that the nonvolatile residue may rise from a value of 6% before, to 10% after, briquetting. Lower order pressures will not bring about a particularly worth-while increase in density.

Since no significant change in chloride volume could be effected readily to permit loading any greatly increased quantity in the reduction furnace, any system requiring additional chloride would necessarily involve a separate generating device.

Magnesium Chloride

REMOVAL

Another problem was the removal of magnesium chloride from the furnace during operation. The volume ratio of magnesium chloride to zirconium formed in reduction is about three to one, indicating that less than one quarter of each reduction crucible load, as distilled, is actually metal. A rather direct approach to the removal of this chloride was tried as shown in Figure 5.

Two pit-type furnaces were connected by a valved pipe line to permit isolation or connection of the furnaces as proposed by Kroll, *et al.* (6). For purposes of this test twice the usual quantity of prepurified chloride from another installation was loaded in the purification furnace. The reduction crucible in the second furnace contained the usual quantity of magnesium while a second charge of magnesium was held molten in a portable ladle as shown. Reaction with the magnesium was carried out by driving zirconium chloride from the purification furnace into the reduction furnace. At the conclusion of the reaction the furnaces were isolated by closing the valve between them and by applying helium pressure to the reduction furnace to drive the magnesium chloride out through the eduction tube provided and into pig molds. When "blow down" was complete, the magnesium ladle was moved into position at the exit of the eduction tube and the second charge of magnesium added to the furnace by blowing it back down this tube by helium pressure. The second reduction was carried out in the same fashion as the first, and at its conclusion magnesium chloride again was blown from the furnace to free the eduction pipe for removal. The reduction crucible was distilled later in the usual fashion.

This approach had several advantages and some definite disadvantages. Since twice the usual amount of zirconium was formed in each reduction crucible, a considerable saving in time was effected since the furnaces did not have to be cooled and reheated between runs. As

a consequence of the double load, twice as much metal was produced in each distillation run. Difficulties encountered in this test from leakage and contamination indicated that a liquid magnesium addition device should be a welded-in component of the system.

Such a system for introduction of molten magnesium was an integral arrangement which dispensed with pipes and connections as shown in Figure 6.

In this arrangement a large cylindrical vessel was welded into the center of the reduction furnace. A magnesium charge was held in the vessel under helium and, at the desired moment, melted by a resistance heater. A central valve rod permitted addition of molten metal to the reduction furnace as desired. It was found that a tight fit was necessary at the magnesium entry valve or a trace of reaction between magnesium and zirconium chloride would either seal the valve in place or form a plug below it. This would prevent the addition of magnesium when desired. With incremental additions of magnesium intermittent operation of this equipment was unsuccessful due to failure of the valve either to open or close properly after the initial usage. No practical application of this apparently simple and direct approach to liquid magnesium addition has been found.

Far more important from the long-range standpoint, was the interference encountered in these tests with back-reaction which occurred when magnesium chloride was removed from the reduction pot, exposing zirconium metal to the action of zirconium tetrachloride. The reaction or reactions which occur apparently are complicated but probably stem from the following:

$$Zr + 3ZrCl_4 \rightleftarrows 4ZrCl_3$$

That the trichloride or perhaps dichloride of zirconium could remain throughout later reaction seems unlikely, but an odd state of metal division or oxidation does remain to cause all manner of trouble through its pyrophoric nature.

GRAVITY DRAINAGE

During the conduct of early work it was shown that molten magnesium chloride would leak through small holes in reduction crucibles having faulty welds, but that molten magnesium was retained because of its higher surface tension. This appeared to make possible the "filtering" off of magnesium chloride as rapidly as formed.

This was tested in the equipment shown in Figure 7. A steel tray having a series of ¼- and ⅜-in. diam. holes was provided for the reaction. These holes were located in the wall so that after 1 in. of reaction mass had formed, magnesium chloride was free to escape.

A test lot of "atomized" magnesium from the Dow Chemical Company was used experimentally. The material, in the form of perfect spheres all less than 1/16-in. diam., was added from a gas-tight hopper as shown. Drainage of magnesium chloride was found successful, but the surface contamination of the "atomized" magnesium contributed oxygen to the zirconium in such quantity that the metal formed was not worthy of further examination.

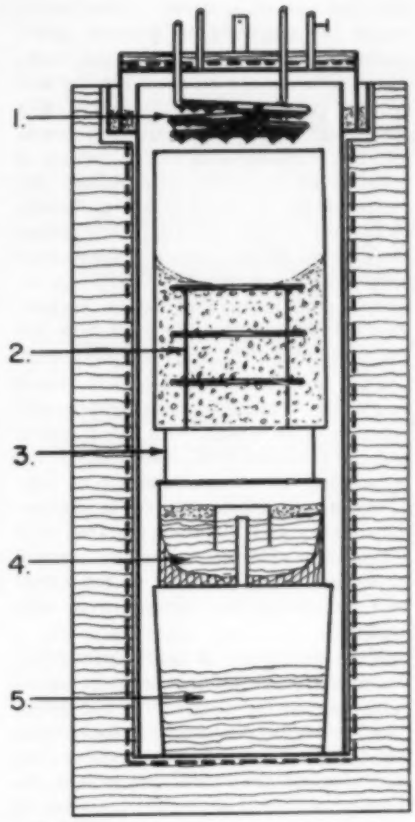

Fig. 9. Weir-type crucible in operation: 1. zirconium chloride control coil; 2. zirconium chloride container; 3. support-baffle, 4. weir crucible; 5. magnesium chloride.

To eliminate this contamination, a gas lock comprised of two ball-type cock valves with a section of pipe between them was employed to add 10-in. slugs cut from 2-in. diam. extruded magnesium rod. The reaction tray at the end of the run is shown in Figure 8. Rate of reaction was high due to the large exposed area of magnesium-saturated zirconium sponge, but back-reaction of the zirconium with zirconium tetrachloride (previously described), was found to be unavoidable in spite of several actions taken to eliminate the vapors at the end of the reaction. All metal produced burned before it could be studied at any length.

WEIR-TYPE REDUCTION CRUCIBLES

To take advantage of the drainage of magnesium chloride and permit greater production of zirconium per reduction pot, a weir pot was developed. This system eliminated the troublesome pipe connections employed in joining furnaces in a side-by-side position by placing the furnaces on top of each other and by using a double-length retort. All

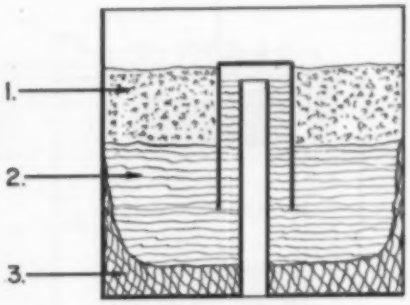

Fig. 10. Weir-type crucible during run: 1. molten magnesium, 2. molten magnesium chloride; 3. zirconium-magnesium mud.

zirconium chloride and magnesium necessary for production of twice the usual quantity of sponge metal were enclosed within the furnace as shown in Figure 9. The system was designed to leave a salt cover for the sponge metal and thus prevent back-reaction. This and the handling of twice the normal quantity of magnesium while permitting the drainage of magnesium chloride is possible through the use of a weir-type overflow (see Figure 10).

minerals processing

In operation the magnesium was placed in the reduction crucible, the required weight of prepurified chloride was placed in the chloride can above, the furnace was conditioned, and temperatures were set for reaction. As reaction occurred, the zirconium formed sank to the bottom as the usual magnesium-zirconium mud. Magnesium chloride took its place between the dense mud in the bottom and the lighter molten magnesium metal which floated on top. As the level rose, a small amount of magnesium was trapped inside the cylindrical weir, but the rising magnesium chloride level soon passed the bottom of the weir and thereafter no more metallic magnesium entered the drain system. It can be seen from Figure 10 that soon after the magnesium was cut off in the weir, it was forced over the top of the drain pipe and passed downward to the salt receiver. Thereafter a continuous flow of magnesium chloride passed through the drainage system until all the magnesium was consumed and the reaction came to a halt.

Well over twice the usual quantity of zirconium has been produced in a single crucible by this method. The metal can be distilled in the usual manner at twice the normal rate, owing to the double weight of metal involved. Metal produced in this manner is satisfactory with the exception of a broad shelf of sponge which fails to sink beneath the magnesium chloride level. Reaction accelerates upon this exposed surface and a considerable reef builds up. Typical of ex-

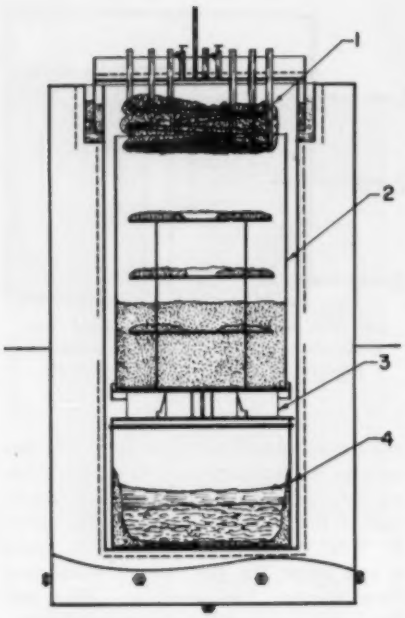

Fig. 11. PR furnace in operation: 1. zirconium chloride control coil; 2. zirconium chloride container; 3. support-baffle; 4. reduction crucible.

posed metal, this becomes covered with a black crust, and despite cautious handling usually burns, when, after distillation, the sponge is broken from the crucible. Several novel methods for covering this sponge by raising the level of magnesium chloride at the conclusion of the run would be possible if actual conditions of the reaction could be ascertained at any given time, but experience has shown this to be too complex an approach.

Materials of Construction

Operation of the production plant has permitted an extended examination of materials of construction for the various pieces of equipment and gear employed in the purification, reduction, and distillation phases of the Kroll process.

Containers for holding crude zirconium chloride during conditioning and sublimation were made originally of mild steel, but the presence of chlorine in this process indicated the advisability of using nickel. Several of these containers were prepared and put into service, but destructive embrittlement soon occurred. Sulfur present in the crude chloride as a residue from a previous operation seemed to cause the embrittlement.

The problem of nickel embrittlement was eliminated by use of Inconel, which meets all requirements for this phase of the work.

Original purification and reduction retorts were of type 347 (niobium stabilized) stainless steel. It was thought that the use of niobium (columbium) would be necessary to prevent grain growth and embrittlement of the stainless steel under the repeated heating and cooling cycles, but replacement of this steel by 25 chromium-20 nickel type was effected without difficulty although a progressive deaustinization along the welds of the 25-20 type led ultimately to the use of type 309 (25-12) stainless steel. This latter steel gives excellent service for purification and reduction retort applications. Distillation furnace tops are at present made from type 316 (molybdenum stabilized) stainless steel.

The reduction crucible was made originally from mild steel, but frequent reaction of zirconium with this material and the resultant iron contamination led to a study of other materials of construction. Graphite proved to be unsatisfactory as it became saturated with magnesium chloride, which by thermal expansion disintegrated it to the extent that the charge was contaminated with carbon.

Next choice was a carbon-containing material–cast iron, excellent in reduction, but during distillation the heavy cast pots slumped beyond permissible limits. Additions of nickel, chromium, and molybdenum to the cast iron in the attempt to bring the creep strength of the cast pots up to a reasonable figure were unsuccessful.

Steel, containing 1% C, is a compromise between cast iron and mild steel and appears to have all the good characteristics of both. Welding of crucibles of 1% carbon steel is difficult. Nickel-chromium stainless steels were not satisfactory as the magnesium metal present in reductions appeared to leach the nickel from the alloy.

A stainless iron, containing 28% Cr, is excellent in that no contamination has ever occurred through its use, but after one heating and cooling cycle the crucible becomes embrittled to such an extent that handling is difficult. Substitution of 14 to 18% chromium steel improves the strength of the crucibles to a useful level and still prevents attack by alloying in all normal operations. This has been adopted now in all production.

The original distillation furnace was of the type 437 stainless steel employed for the first reduction retorts. This was replaced by more economical mild steel with an external flame-sprayed coating of aluminum to retard oxidation. This was quite satisfactory, with the exception of the blistering caused by the inevitable one or two tiny pinholes present in each coating. Replacement of the heated portion of all retorts with type 316 stainless steel has been a great economy and is practiced in the plant today.

REMOVAL OF REDUCTION BY-PRODUCTS BY VACUUM DISTILLATION

The elimination of by-product magnesium chloride and excess magnesium is a relatively straightforward operation, but several variations on the original method have increased the efficiency of the procedure.

The main problem in distillation was the extensive delay encountered in cooling the equipment after the distillation proper was over. First saving in time was effected by admitting helium gas to the retort when the temperature had fallen to 450° C. The presence of a heat-conducting gas in the system which previously had cooled under high vacuum permitted a saving of about 2 hr./run.

It was obvious that for effective cooling the bell-type heating furnace should be removed, yet with the mild-steel retorts this was impossible since the retort was so weak at this temperature it could not withstand any pressure differential. When the mild-steel tops were replaced by type 316 stainless steel, it was possible to remove the furnace without damage to the equipment. A series of spray nozzles was arranged to play upon the retort after removal of the furnace in order to accelerate further the cooling with a resultant time saving of about 6 hr./run.

Early distillations in which the reduction crucible was of mild steel had to be heated up cautiously to prevent the temperature from exceeding 935° C. locally with formation of the zirconium-iron eutectic. With the advent of the use of 14% Cr iron reduction crucibles, the distillation furnace could be heated up without hesitation, effecting a time saving of 3 to 5 hr. These improvements and advanced techniques for unloading and cleaning the distillation retorts have reduced the time for a run from 55 to 30 hr., without any decrease in the quality of sponge produced.

A development which is not yet in production is the "lined reduction crucible." This technique can double the productive capacity of the distillation furnaces by doubling the charge that can be loaded in a given crucible. The lined reduction crucible is just as described by the name—a reduction crucible with a sheet-metal liner. This liner is made from 28 gauge steel, containing either 14% Cr or 1% C to prevent reaction with the zirconium. The reduction takes place within the light gauge pot which is supported mechanically by a standard crucible. At the conclusion of the reduction operation, the furnace is cooled and the reduction crucible removed and inverted which causes the reduction mass in the liner to slip out. The liner is cut down one side with a chisel and peeled off by simply pulling on it. The great bulk of by-product magnesium chloride is removed with an ax, and the metal mass quartered by sawing. Metal from at least two runs can be loaded into a standard size reduction crucible for the distillation step. Successful operation of this system depends upon a special low-humidity room for the peeling operation.

Present Technique of Operation

The many tests and examinations carried out have resulted in an improved method for producing zirconium termed the combination purification-reduction or PR method.

This method is based upon the discovery that crude zirconium chloride heated to 200° C. and outgassed by reducing furnace pressure to about 25 mm. Hg may be employed directly in reduction work without prior sublimation. Furnace equipment and arrangement are shown in Figure 11. The reduction crucible containing a charge of 120 lb. of pig magnesium is loaded in the bottom of the furnace, followed by the support baffle and the chloride charge can containing about 525 lb. of crude zirconium chloride. The furnace is closed and evacuated by a water-jet pump to a pressure of 25 mm. Hg or less, while the furnace comes up to a temperature of 300° C. When the pressure has been reduced to 25 mm., helium gas is added to atmospheric pressure and the furnace allowed to soak for 2 hr. During this period any pressure arising from thermal expansion of the furnace atmosphere is bled off intermittently through a valve. At the conclusion of the 2-hr. soak, the furnace is evacuated to 25 mm. pressure twice, filling each time with helium. This is followed by another 2-hr. soak at the conclusion of which all chloride is at, or above, 200° C. The lower zone of the furnace is then raised to 825° C. to melt the magnesium while water is applied to the condensing coil to permit the addition of helium to the furnace atmosphere. A highly empirical system is employed in obtaining the desired mixture of helium and zirconium chloride in the furnace that will permit a rapid, yet controlled reaction. If too much helium is present, the reaction may proceed too slowly; if too little helium is present, the reaction will become violent and boil over the top of the reduction crucible, causing an expensive shut-down of the equipment. By strict adherence to the prescribed technique the operator can keep a PR reaction on schedule, a particularly valuable situation, as this permits one operator to handle four reactors without any two of them demanding attention at the same time. The bulk of the PR run is carried out in the most efficient phase of reduction, and before the old finishing stage is entered, the reaction is shut down.

Several important changes over the old two-step process may be shown best by the time graph, Figure 12. Savings accrue both from the regular schedule of operation of the PR runs and from the fact that the cooling and heating cycle between the purification and reduction steps is eliminated. Over-all increase in efficiency virtually has doubled the output of the plant to a figure of nearly 4 tons/week. A direct comparison of output is not possible because of the greatly increased effectiveness of manpower in the plant brought about through improved training and supervision.

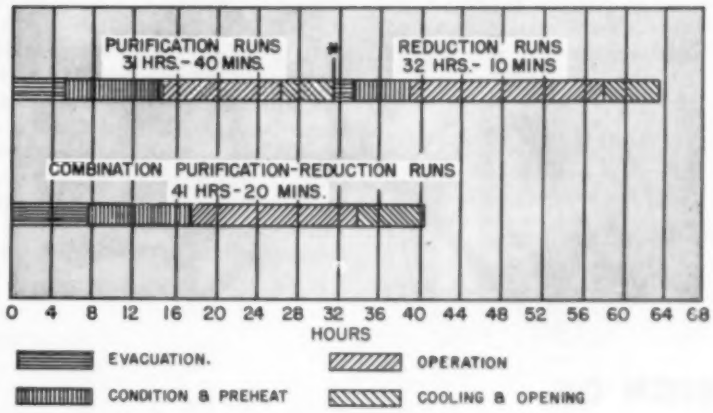

Fig. 12.

Summary

The mechanism of the reaction of magnesium and zirconium tetrachloride has been studied on an operational scale. Zirconium is reduced in microparticles which form a mudlike suspension with the molten magnesium metal present. This suspension may contain up to 45% Zr and still retain some degree of fluidity. This property is not of much assistance in the development of a continuous process since the mud cannot be pumped, scraped, or handled without the formation of massive zirconium, which adheres strongly to all materials of construction.

Improvements based on research findings have been incorporated in all phases of the zirconium production work at Albany. Reduction efficiency has been raised through various stages to the present combined system in which purification and reduction of the zirconium chloride takes place within a single furnace in one operation. Over-all effectiveness of the plant has been doubled in three years, with only limited equipment changes. Removal of the by-products of reduction by vacuum distillation has kept pace with the increase in reduction capacity of the plant through developments in quick heating and cooling of the furnace.

Acknowledgment

Acknowledgment is made to Admiral Hyman G. Rickover, of the U. S. Navy Bureau of Ships, without whose foresight this work would not have been performed. The research phase of the program has been concluded under the supervision of A. D. Abraham and F. E. Block. Suggestions and encouragement of S. M. Shelton, W. W. Stephens, E. D. Dilling, and G. C. Ware are appreciated. Cooperation of plant personnel supervised by H. P. Holmes and D. W. Richardson was, of course, of prime importance in the application of developmental systems to plant production.

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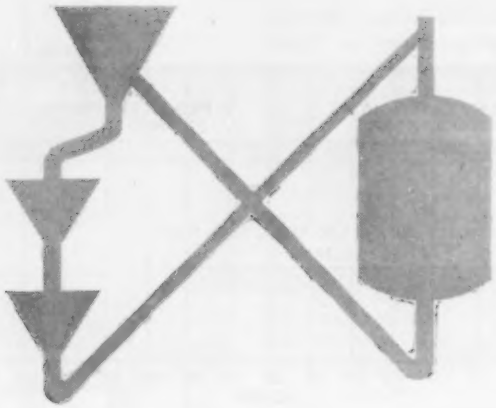


DESIGN OF process systems UTILIZING MOVING BEDS

Clyde Berg | Union Oil Company of California, Wilmington, California

The movement and handling of solids as an integral part of processing operations has undergone rapid stimulus during the past decade with the advent of many new processes employing solids handling as a basic operation. World-wide installation of moving solids bed catalytic-cracking units by the petroleum industry, followed by the utilization of moving beds of activated carbon for separation of gases, the use of moving catalyst beds in gasoline reforming, and of moving coke beds in the thermal coking of petroleum, as well as the newer techniques of shale retorting are some of the major advances in this field. In the above-mentioned operations, handling of solids is part of the processing operation and the principal product is either a gas or liquid.

With the requirements for increased knowledge and techniques for handling of solids have come new methods for solids transfer, new methods of solids-level flow control, precise understanding and process techniques for control of solids movement through contacting beds.

The growth in importance of solids handling in catalytic processing has been outstanding. Today, a major portion of all petroleum catalytic processing involves operation over moving catalyst beds.

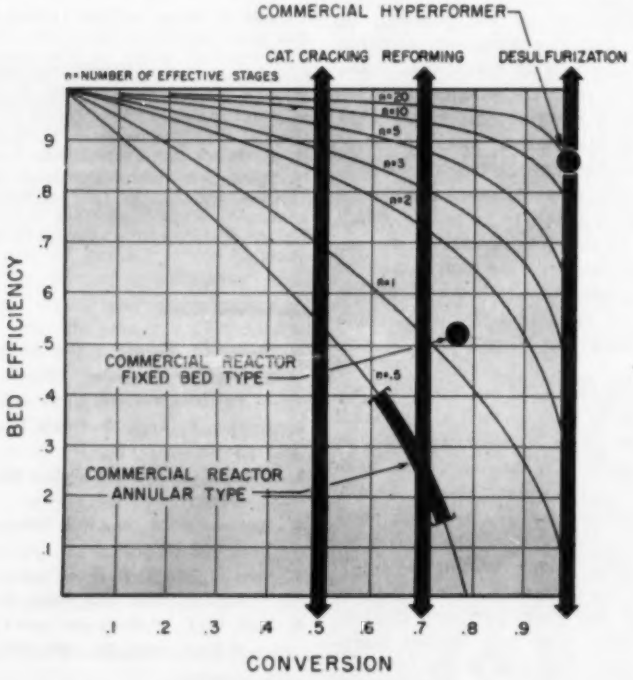


Fig. 1. Reactor performance.

Process Considerations

When a reaction is found to proceed in the presence of a catalyst or special carrier, replenishment of the solids in the reactor is generally required to maintain continuous process conditions. The ability to carry out operations on a continuous basis generally leads to economies in over-all heat balance, construction and operating costs of a processing unit. With the accelerated research and technical efforts carried out during the past decade, it is not surprising that major advances have been made in this field. In some processes the circulation of solids and catalytic material is carried out to effect heat balance, thereby avoiding furnaces and heat exchangers which otherwise would be required. In other processes catalyst circulation is carried out primarily to rejuvenate its activity, in effect to maintain optimum conditions in the reactor to assure maximum yields and quality of the process product. In certain cases the circulated material may serve as a surface-generating medium with a continuous solids-liquid mixing operation as a fundamental step in the over-all process operation.

In all these operations the circulated solids stream is processed for heat and material-balance optimums just as in fluid processing. A precise intermeshing of mechanical and processing techniques is required in crystallizing the design of processes of this type. Rather detailed engineering analyses must be made of every phase of the solids-handling cycle to assure proper plant performance.

Reactor Design

An integrated tower-type construction is generally preferable for catalytic reactor design and provides the compactness necessary for good engineering and economy of construction. Reactor temperature is dominated by either the solids circulation or the fluid stream, depending upon which has the greater heat capacity. In either case the temperature profile may be controlled by the introduction of external fluid streams or by the use of external and internal heat exchangers.

REACTOR SHAPE

In a moving-bed as well as a fixed-bed reactor, there is possibility of by-passing the fresh or partially converted feed past sections of the catalyst bed. This probability is increased as the ratio of diameter to length of the bed is increased. A large-diameter squat reactor leads to a greater possibility of by-passing the feed than that of a narrow, slender reactor. Based on extensive studies, the requirements of a commercial-plant reactor performance can be correlated quite accurately by recognized probability methods. The efficiency of a catalytic reactor is regulated by two factors: (1) the conversion level at which the reactor must be operated, and (2) the length to diameter of the reactor which determines the effective number of stages of contact. Figure 1 presents a generalized correlation of these relationships for reactor design. It will be noted that catalytic-cracking operations are only mildly affected by the shape of the reactor since conversions on the order of only 50% are involved. In the case of reforming operations on straight-run gasoline, conversion approaches 70% but is still not critical as regards the length to diameter of the reactor. In the case of the desulfurization of high-sulfur petroleum stocks and chemical reactions where conversions approaching 98–99% must be obtained, the shape of the reactor is indeed critical and care must be utilized in the over-all reactor design to assure freedom of by-passing effect.

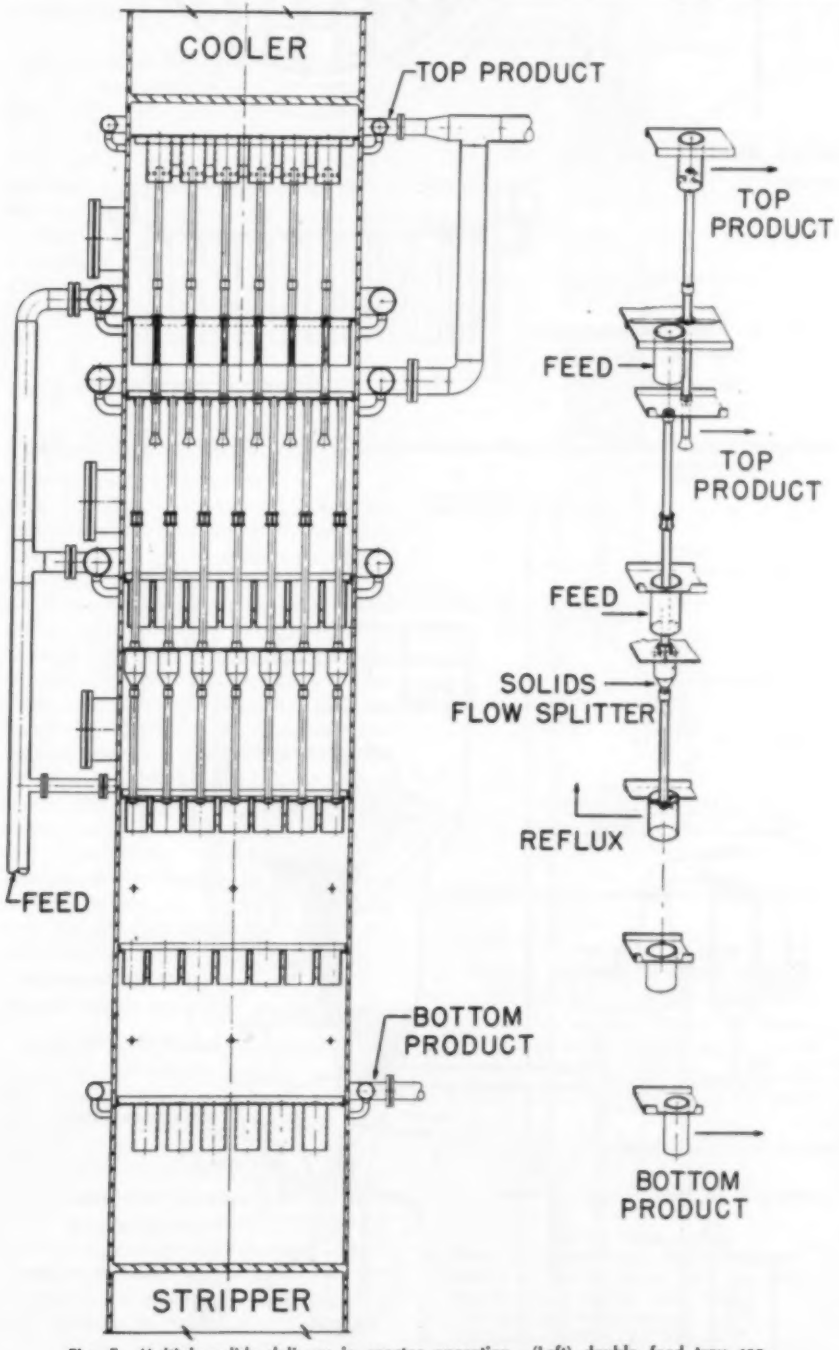


Fig. 5. Multiple solids delivery in reactor operation. (Left) double feed tray construction details in Hypersorption unit; (right) isometric of solids-flow equipment.

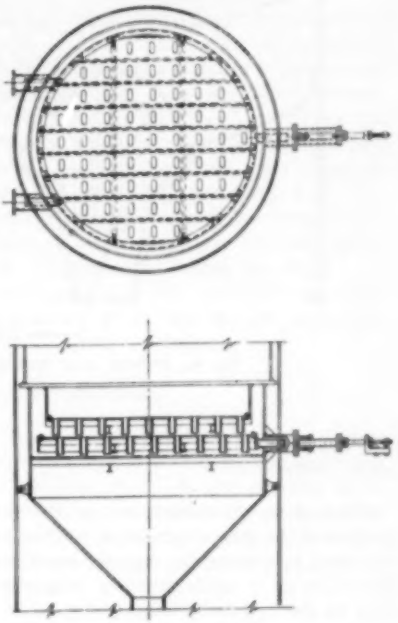


Fig. 2. Reactor solids-flow distribution control mechanism.

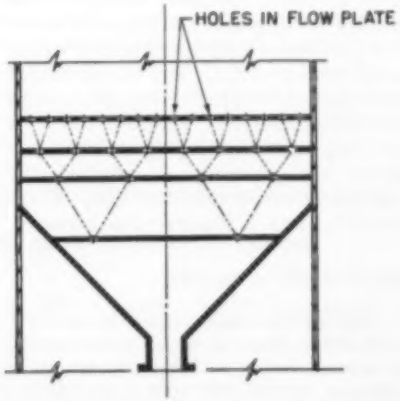


Fig. 3. Perforated tray type of reactor flow-distribution control.

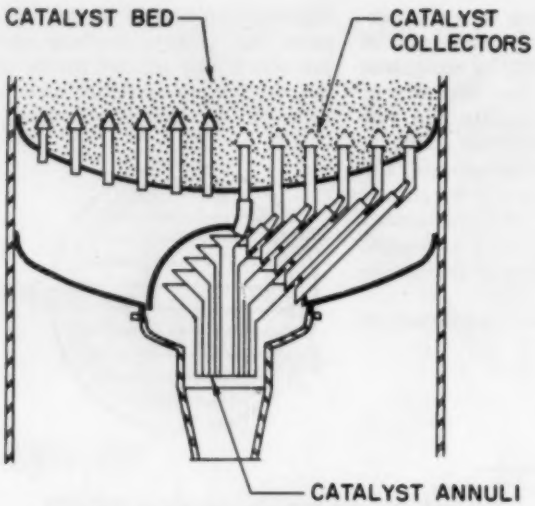
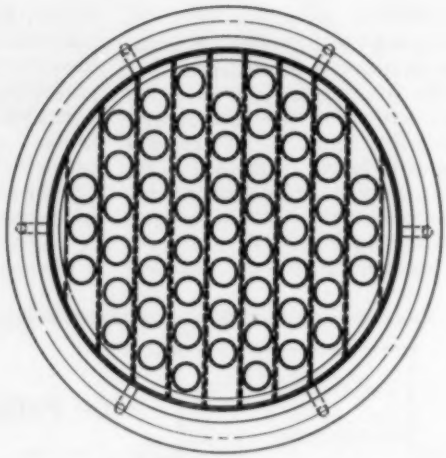


Fig. 4. Inclined pipe type of flow-distribution control.



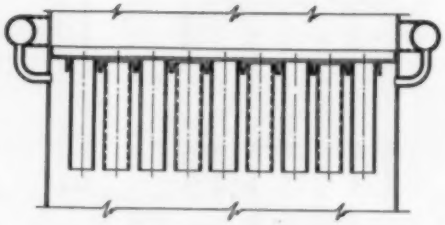


Fig. 6. Vapor disengaging-engaging tray.

SOLIDS FLOW

Solids-flow considerations must regard first the proper entrance and exit for solids movement through the reactor. The manner of solids removal from the base of the reactor is quite critical. In this aspect of reactor design, it is important that solids must be removed uniformly from the base of the reactor since any nonuniformity will be reflected by disturbed solids-flow patterns extending well up in the reactor.

A positive-flow control device for distribution control at the base of a reactor is illustrated in Figure 2. It employs a moving tray with multiple downspouts used to remove a precise amount of solids across each increment at the base of the reactor. The various downspouts are filled at one extremity of its motion and emptied at the other extremity of its motion. This general design of solids-flow control is used in the processes of Hypersorption and Hyperforming. Other techniques using the principle of solids-flow dynamics have been developed to effect uniform solids motion at this point; and Figure 3 shows the perforated tray construction widely employed in T.C.C. and Houdry flow unit operations (*1, 2*). Another design of this general type involves a nest of inclined pipes discharging at a common point and drawing at geometrically spaced points across the base of the reactor. This is illustrated in Figure 4.

MULTIPLE SOLIDS DELIVERY

Sometimes multiple solids delivery and solids removal in a reactor having a contact bed are desired. This can be effected by careful application of the principles of solids flow; Figure 5 illustrates a contacting bed of a double-feed

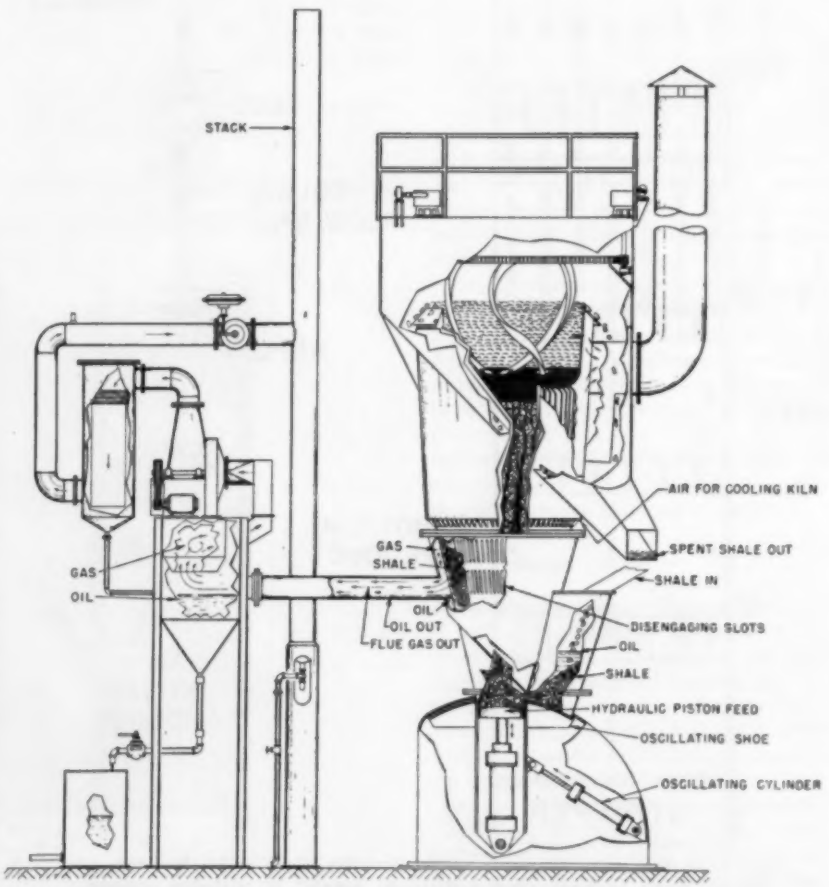


Fig. 8. Union upflow shale retort.

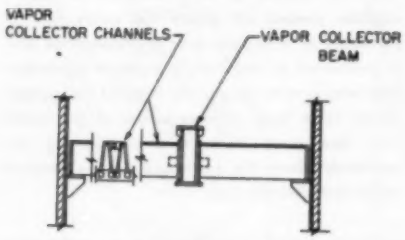


Fig. 7. Vapor disengaging tray.

Hypersorption unit where solids are fed to two independent solids contacting beds (*3*). The general principles involved are illustrated in the diagram of this figure where it is shown that a common solids entry pipe is provided to the two contacting sections and an independent solids removal is provided through a flow splitter which, in this case, provides equal flow to each of the beds as the solids circulation is carried out.

VAPOR INTRODUCTION AND REMOVAL

The introduction or disengaging of a fluid stream in the reactor should provide maximum uniformity of gas or fluid introduction and a minimum disturbance to the uniformity of the solids-flow pattern. Figure 6 shows a typical disengaging tray (*4*) used in Hypersorption and Hyperforming, wherein the solids are permitted to flow down through downspouts and the gas distributes itself through the tray and then flows countercurrently to the solids motion in the downspouts. Another introduction technique involves a spider-like construction with fingers extending across the reactor bed. This general construction is used widely in T.C.C. and Houdriflow operations (*1, 2*), wherein the catalyst is moved over a convex surface or inverted V section with the gas removed from beneath the umbrella-like section (see Figure 7).

UPFLOW SOLIDS MOVEMENT

Reactor operations may involve the movement of solids upward and the fluid stream downward in contrast to the considerations just outlined. An example of this type of design is given in Figure 8 (Union shale retort), wherein the solids are introduced at the base of the unit by a plunger-operated feeder mechanism, are moved upward through tapered sections, and are discharged overhead by a scraping mechanism. The fluid medium is passed down countercurrently to the rising solids. In this general-type design certain special considerations must be weighed. No appreciable obstruction can be inserted into the reactor and the sections must be expanded outward to prevent solids pressure build-up in the course of movement. Solids-flow channeling is much less of a problem in this type operation since the solid material tends to mesh together as a plug with slippage at the wall preventing appreciable deviation from the uniform flow pattern.

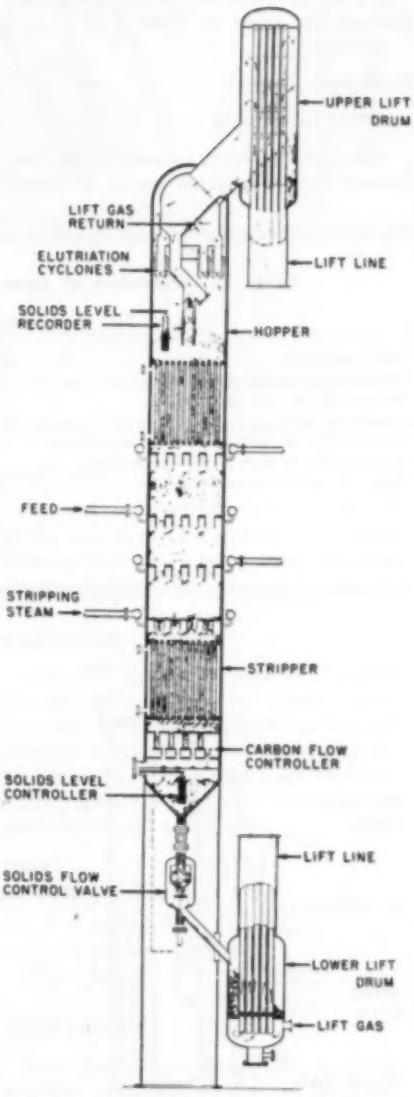


Fig. 9. Dilute-phase gas lift in Hypersorption process.

Solids Conveyance

The solids transfer technique utilized in setting up a processing system affects the over-all characteristics of the process probably more than any other feature. It directly affects the location of the various contact vessels, solids transport lines, considerations in fines removal, possible operating pressures and temperatures, requirement for lock chambers, as well as attrition loss and make-up requirements. There are three general types of solids transport generally available; these are, bucket elevators, gas lift, and Hyperflow.

BUCKET ELEVATOR

Bucket-elevator technique has been widely used in the older type T.C.C. cracking operations. In this application, units with capacities up to 500 tons/hr. and catalyst temperatures 900 to 1,000° have been built. Most of the earlier installations involved capacities on the order of 150 tons/hr.

process design

PNEUMATIC CONVEYING

The pneumatic-conveying techniques have been widely used as a method for moving solids bed systems in the Hypersorption process gas lift, as well as in Houdriflow cracking, T.C.C., and other processes. In Figure 9 the diagram of a Hypersorption unit with gas lift of solids circulation is presented (3). It will be noted that in this general design, multiple parallel tubes are used together with enlarged inlet and discharge vessels at top and bottom of the conveying section. The gas-lift systems in Hypersorption employ a number of specialized internals of a highly refined nature to reduce attrition of the valuable material being conveyed. They operate with a pressure drop of 1 to 2 lb. across the lift line while careful consideration is given to all sections of the line to avoid breakage due to impact or excessive turbulence.

Table 1.—Comparison of Hyperflow and Dilute Phase Solids Transfer

Dilute Phase	Hyperflow
1. Solids suspended in gas stream: apparent density of flowing stream much less than that of gravity-packed solids mass.	1. Solids in compact unfluidized mass: density of flowing stream substantially the same as a compact downward-moving solids bed.
2. High gas and solids velocity.	2. Low gas and solids velocity.
3. Low-pressure differential required.	3. High-pressure differential required.
4. Large quantities of lift gas required.	4. Small quantities of lift gas required.

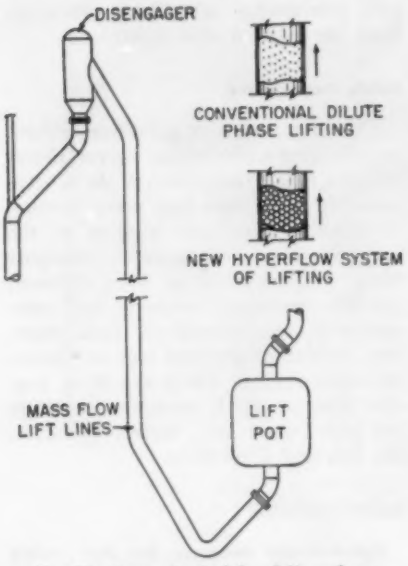


Fig. 10. General principle of Hyperflow.

HYPERFLOW

The Hyperflow solids transfer technique is the newest method of solids transfer (6). It employs a completely new phenomenon in solids handling and some of the distinctions between this and gas lift are given in Table 1.

Hyperflow may be considered a reverse gravity conveyance system where each particle is pressing on each particle surrounding it. The particles move as a mass in the direction of transport rather than being suspended and dispersed from one another as in dilute-phase lift. This technique has features affecting the design of any process unit involving the movement of solids and permits the elimination of sealing legs, more compact structure, and reduced investment costs. Because of the lack of turbulence, greatly reduced attrition effects and substantial economies are achieved in Hyperflow. The general principle of Hyperflow is brought out in Figure 10, and it will be noted that a pressuring pot is at the base of the lift line. Rather small quantities of gas are required for the operation of the lift line. The differential across the lift line is appreciably higher than that in dilute-phase conveyance. Figure 11 reveals an application of the Hyperflow solids-flow transfer technique in the Hyperforming process. As the solids are circulated through the base of the reactor through a pressuring pot, a rather small lift line carries the solids to the top of the reactor where a small amount of gas flow is disengaged and the solids returned to the reaction vessel proper.

RELATIVE FEATURES

A comparison of the methods of solids transport is given in Table 2 (*5*).

Solids-flow Control

DISK-TYPE FLOW VALVE

Every solids-circulating process system requires a means of solids-flow control. In Figure 12 is illustrated a highly refined solids-flow control valve typical of those used in the Hypersorption process (4) where the solids flow is permitted to disengage over a circular disk and is positioned to maintain a constant solids-flow rate over a wide range. An integral disengager in the valve body releases surges of gas which may flow down through a sealing leg immediately above the valve and assures constant solids-flow characteristics.

Table 2.—Comparison of Three Methods of Solids Conveying

	Bucket Elevators	Gas Lift	Hyperflow
Solid velocities	20-120 ft./min.	15-40 ft./sec.	Low
Pressure differential required	None	Low	High
Amount of lift gas required	None	Large	Small
Investment cost	High	Low	Low
Adaptability to high-temperature operations	Poor	Good	Good
Adaptability to high-pressure operations	Fair	Fair	Good
Rates of solids transport	500 tons/hr. max. (in commercially available units)	400 tons/hr. (in a 27-in. lift pipe)	900 tons/hr. (in a 12-in. line)

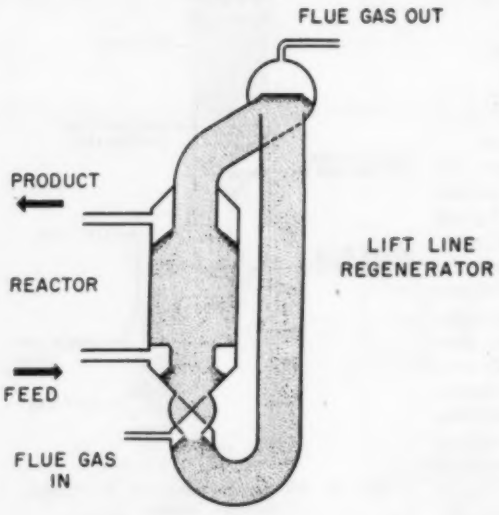


Fig. 11. Application of Hyperflow in the Hyperforming process.

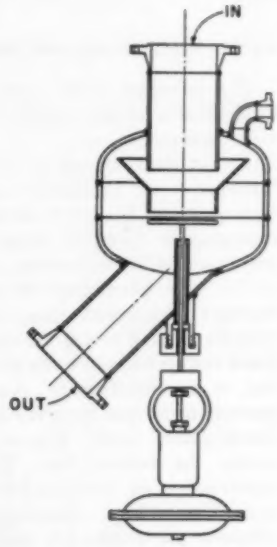


Fig. 12. Solids-flow valve (Hypersorption process).

Fig. 13. Star feeder.

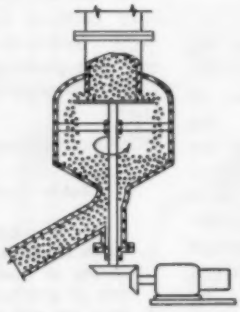


Fig. 14. Rotary table feeder.

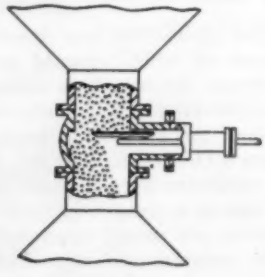


Fig. 15. Slide valve solids-flow control.

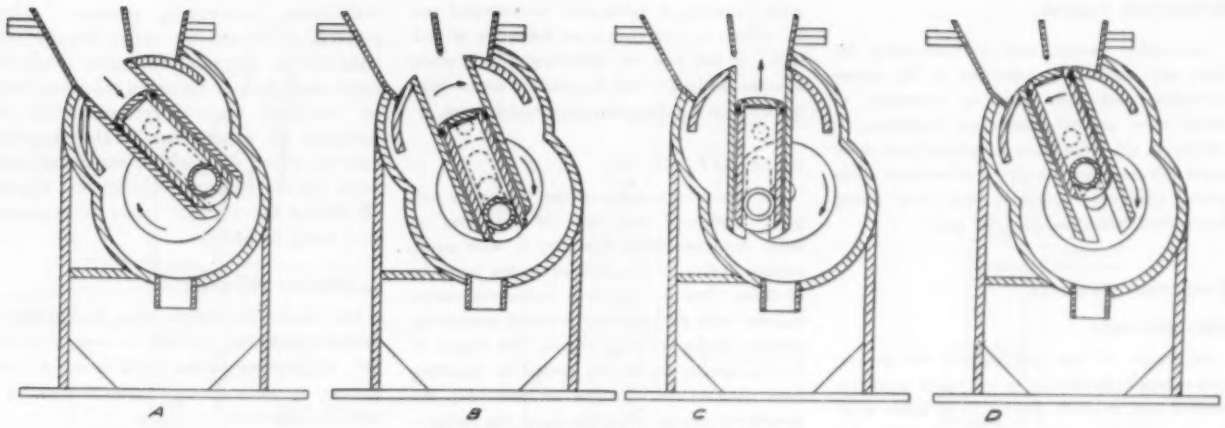


Fig. 16. Piston-type solids feeder (upflow).

RECIPROCATING TRAY FEEDER

A reciprocating tray feeder has been described in a previous section of reactor design (Figure 2) and involves both solids and flow-distribution control. Where this reciprocating-tray type is incorporated in the reactor, an external flow-control valve is not required to set circulation rate.

STAR FEEDER

The star feeder is an elementary type of solids-flow control device offering positive displacement control of the delivery rate. This type of feeder is convenient where moderate conditions exist but difficult to design under elevated temperatures or pressures or where abrasive materials must be handled. An illustration of a typical star feeder is given in Figure 13.

ROTARY TABLE FEEDER

The general design of a rotary table feeder is given in Figure 14. This device utilizes the natural tendency of pellets to seek their angle of repose and prevent discharge above the rotating table. Rotation disturbs this condition and causes flow at a rate varying with the speed.

SLIDE VALVE

The slide valve in Figure 15 illustrates one of the most elementary solids-flow slide valves which by varying the aperture setting determine the rate of flow.

ORIFICE FLOW CONTROL

Solids flow can be controlled at a constant rate by a fixed orifice. In this general application solids delivery differs from the general consideration of fluid flow in that it is largely independent of the depth of solids above the orifice. A fairly general equation for development of solids flow through orifices is (1):

where

$F = 8.50D^{2.05}H^{0.04}$

F = catalyst flow, lb./min.

D = orifice diameter, in.

H = head, ft.

SCREW FEEDER

Screw feeders may be employed to control solids-flow rate and in this general application rotation rate of the screw sets the solids-delivery rate. For such a device consideration must be given to prevent surging gas flows from affecting the delivery rate from the screw feeder.

PLUNGER FEEDER FOR UPFLOW

Where solids move upward through a contact chamber, an entirely new type of solids-flow control equipment is utilized. Figure 16 illustrates the positive displacement feed mechanism utilized at the base of the Union shale retort. Rate of delivery is controlled by varying the number of strokes per minute of the displacement piston. The basic principle of this feeder (as noted) is that of a reciprocating piston mounted on trunions permitting it to swing into an inclined position for filling and then to swing back into a vertical position for discharge.

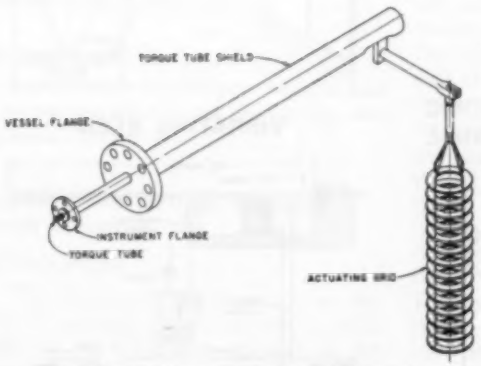


Fig. 17. Grid response level measuring unit.

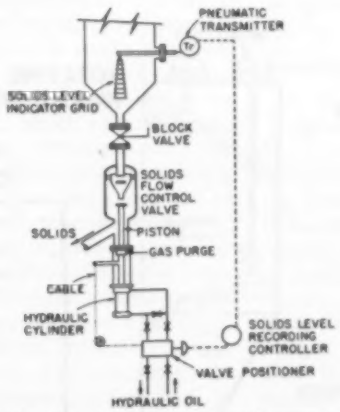


Fig. 18. Application of grid response unit to solids level control.

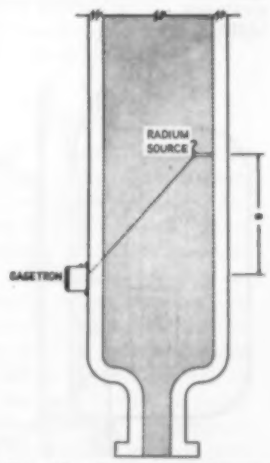


Fig. 19. Gamma-ray detector level measure.

Solids-level Control

Solids-level control and level-indicating devices are particularly important in the newer processing techniques involving movement of solids under precisely controlled conditions. A variety of types has been developed and these types fall into two general classifications: those giving continuous response, and those giving intermittent indication of solids level.

Continuous Response

GRID RESPONSE

In Figure 17 one can observe the grid-response-type level measuring unit which gives continuous and dynamic indication of solids level. It permits instrumentation and control in solids handling comparable to that obtained in the handling of fluids. By the insertion of a grid into the moving bed of solids, it measures directly the internal forces which are specifically related to the density of the material being handled and the particular bed depth. Response of the unit is not significantly affected by the mesh range of the solids being handled, but application is restricted to continuously moving beds of solids. As illustrated, the grid consists of thin metal rings connected by rods to form a vertical cylinder. Normally, the grid element is constructed integral to a torque tube mechanism and actuates an external air pilot unit. Grid-response units may be used in processing operations with high temperatures and high pressures. Figure 18 illustrates a typical application of grid-response-type solids-level control. The same principle of solids-level measurement can be utilized to give continuous indication of bed level. In this case the cylindrical grid is made of extended length and the pressure output from the air pilot is calibrated against solids level.

GAMMA-RAY DETECTOR

The gamma-ray detector-type measuring unit gives continuous indication of variations in solids level permitting flexibility in most applications similar to that utilized in the handling of fluids. This unit utilizes a radioactive source together with an externally mounted gamma-ray detector as the actuating device. (See Figure 19 for the application of this device for throttling level control.) In this type of instrument, the gamma-ray source is located above the detector. As the level of solids being controlled rises in the vessel, the mass between the radiating source and the detector increases to absorb more gamma rays; this directly affects the detector and the output to the electronic recording controller.

WEIGHING METHODS

Solid level in a vessel bin may be weighed by actually measuring the total weight of the vessel and its contents. Although precise measurements are possible by this means, it is rarely possible in continuous processing systems.

Intermittent Level Indicators

The intermittent-type level indicators are generally used for the actuation of alarm systems and signaling devices in continuous processing systems. They generally depend on some simple mechanical or physical response measurement and do not incorporate pneumatic or electrical control systems with the features of proportional rate response control, reset, etc., which can be utilized with the foregoing techniques. Figure 20 shows the various types of intermittent level indicators.

DIAPHRAGM RESPONSE

The diaphragm-response type incorporates a flexible diaphragm exposed to material in the bin. As pressure of the solids forces the diaphragm against a counterweighed mechanism, a switch is actuated.

PENDANT CONE

Another device incorporates a plastic float or a metal cone at the end of a pendant rod mounted in a universal pivot column, and deflection actuates a switch.

PROBE DEFLECTION

The probe-deflection type utilizes a tapered steel rod which when deflected actuates a switch.

ELECTRICAL CONTACT

Application of electrical-contact type is restricted to solids possessing an appreciable electric conductivity. Contact with the probe completes an electric circuit and actuates one or more switches.

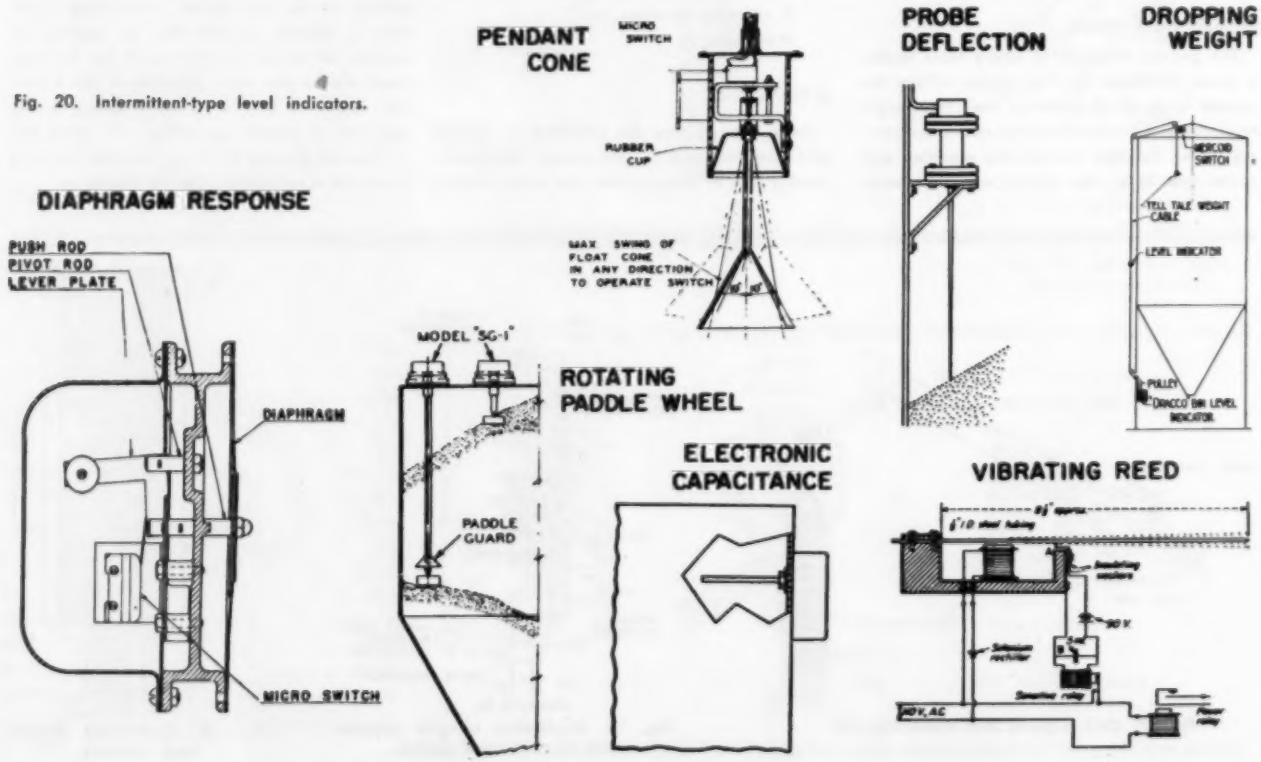


Fig. 20. Intermittent-type level indicators.

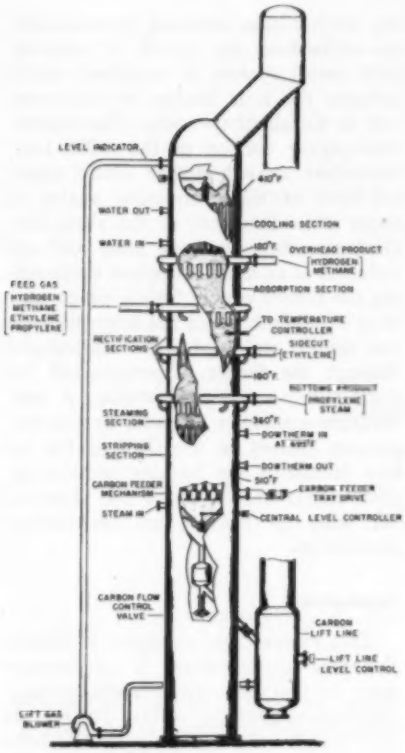


Fig. 21. Hypersorption unit.

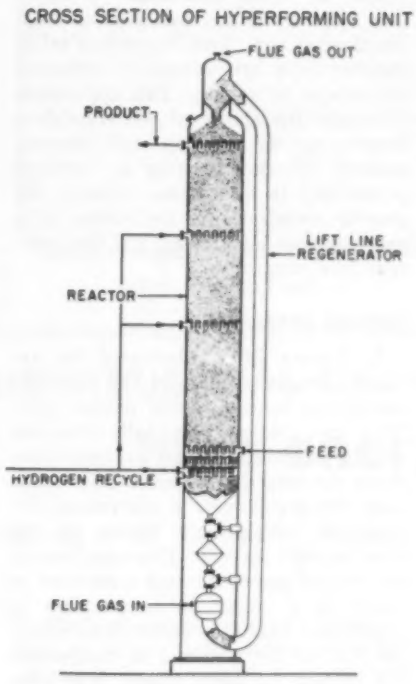


Fig. 22. Hyperforming unit (unitized).

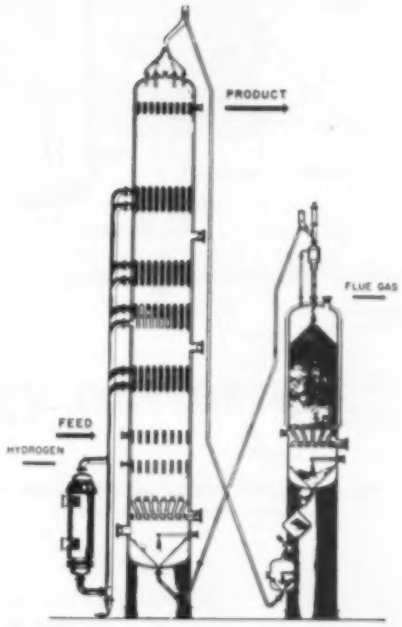


Fig. 23. Hyperforming unit (double-vessel design).

ROTATING PADDLE WHEEL

Another type employs a paddle wheel driven by a synchronous motor. When rotation of the paddle is resisted by a solids material, the force causes the motor supports and gear housing to rotate an actuating switch.

ELECTRONIC CAPACITANCE

Another type of response element is designed as a condenser. The dielectric constant of the solids directly affects the capacity of the pickup unit which in turn operates an electronic control system.

DROPPING-WEIGHT

The dropping-weight-type level indicator is primarily designed to measure the contents of material stored in bins.

VIBRATING REED

Another type is actuated when the solids level rises high enough to restrict the vibrating of a magnetic vibrating reed.

Typical Process Systems Employing Solids Circulation

HYPERSORPTION

The Hypersorption process is an excellent example of the combination of a number of techniques outlined in the preceding discussions. Its basic operation employs a moving bed of activated carbon to absorb and fractionate the components of the gas stream. The phenomenon of adsorption in this process provides unusual selectivity for the recovery and separation of relatively volatile hydrocarbon gases as well as other components. Activated carbon provides the retentive forces necessary for high-efficiency recovery for volatile constituents, yet unlike other separation media, this high-retentive power can be released under desorption conditions, and stripping is effected with ease. Figure 21 is a diagram of a Hypersorption unit of modern design (*3*). The processing conditions indicated are typical of a unit recovering ethylene from a gas produced by high-temperature cracking. It will be noted that in external appearance this unit resembles a single tall fractionating tower. Its principal distinctive feature is a lift line attached to the side of the tower which effects circulation of the solids within the tower by transport as a dilute suspension in a gas stream. The cutaway sections of the diagram reveal that the tower has two heat-exchange sections: a cooler at the top and a Dowtherm-heated stripper exchanger at the bottom. Between the cooler and the stripper are four trays. The feed, introduced through a distribution tray, passes countercurrently to the moving activated carbon and is disengaged as lean overhead product through a tray immediately below the cooling section at the top of the unit.

The adsorbed material is produced as two streams; the disengaging tray immediately below the feed point releases the intermediate ethylene product, whereas the disengaging tray near the bottom of the unit, just above the stripping section, disengages propylene and steam. Separations are controlled by conventional temperature controllers actuated by a temperature profile generated as a result of the adsorption effects occurring at various levels in the tower.

HYPERFORMING

A diagram of a Hyperforming unit is shown in Figure 22. This process is a general-purpose reforming and stock-upgrading operation which utilizes the new Hyperflow catalyst-movement technique (*7*). It carries out the reforming of straight-run naphthas as well as straight-run and cracking stocks. The reactor incorporates a solids-handling feeder which offers precise control of catalyst at all points. It will be noted that the catalyst moves downward through the reactor under gravity flow and is returned to the top of the reactor by means of mass conveyance in a catalyst transfer line. Simultaneous with

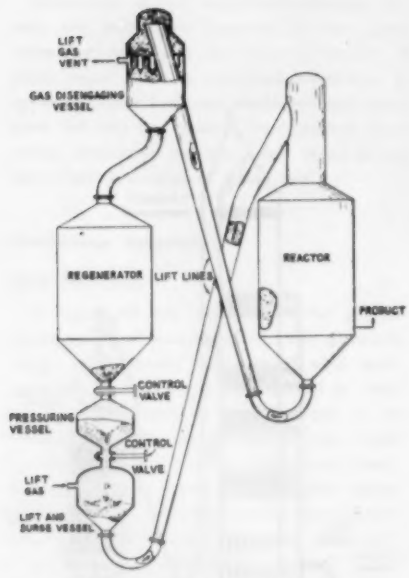


Fig. 24. Reactor reheater section, Lummus continuous contact coking unit.

this mass lift, regeneration is carried out. The feed naphtha is introduced into the bottom of the reactor and the recycle gas is introduced somewhat below. The bottom streams flow upward countercurrently to the catalyst and hot hydrogen is introduced at several interheating points. The reformed naphtha leaves the top of the reactor as a thoroughly refined product. Catalyst enters the lift system through a simple lock located at the base of the reactor. In the lift line the combination of a moving bed and a controlled oxygen content limits the peak temperature rise in coke burn-off; thus moderate conditions in coke burn-off from the catalyst are assured.

An illustration of a double-reactor design of the Hyperforming process, wherein regeneration of the spent catalyst is carried out in a separate vessel, is shown in Figure 23. This design also shows the use of external interheaters to reheat the mixture of naphthas and recycle gas that pass through the catalyst bed. Two Hyperflow solids transfer lines are utilized to circulate the catalyst to vessels. This application illustrates the ability of the Hyperflow lines to act as effective seals between reaction vessels operating at different pressures. It also shows clearly the general techniques of application of a reciprocating tray feeder and the grid-type level controller.

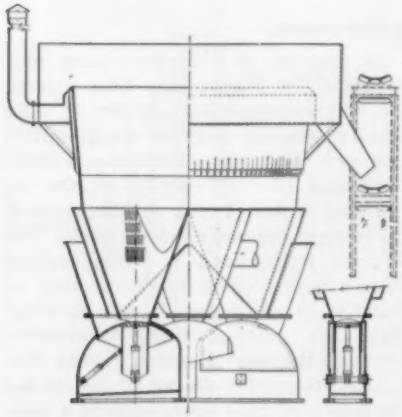


Fig. 25. 1,000 ton/day shale retort.

CONTACT COKING

In Figure 24 is illustrated the reactor reheater section of the Lummus continuous contact coking process (*8*). This unit consists essentially of a reactor in which oil-wetted granular coke flows downward in a dense bed. Sufficient time is allowed in the reactor for cracking, coking, and drying on the coke particle surface. The coke leaving the reactor passes through a reheater in which it is raised in temperature to supply the heat of reaction from sensible heat to the feed and to compensate for certain radiation losses. The coke circulating system uses the Hyperflow principle to move the coke in a dense, unactivated column and at high-flow rates. As the coking operation proceeds, successive increments of coke layers are deposited on the particles in the circulating mass and a gradual increase in coke particles occurs. The larger particles which have a diameter of approximately 1½ in. or more are drawn off continuously and are produced as coke to maintain a constant inventory in the system. Not shown in Figure 24 is the rotary star feeder above the reheater which controls the rate of coke flow. A feeder of this general type is shown in Figure 13. Only one coke level must be controlled—that in the reheater. The coke circulation rate is increased or decreased by adjusting the rate of the rotary star feeder.

UNION SHALE RETORT

In Figure 25 is illustrated a 1,000 ton/day Union shale retort. This unit employs countercurrent flow of shale and air in a kiln utilizing a bottom feed of solids. Ash and clinkers are removed overhead and the oil drained from the bottom of the unit is cooled by countercurrent heat exchange with the incoming shale. No water is required for process operation. Movement of the shale through this unit is effected by a hydraulically operated underfeed mechanism. The shale kiln employs an external shale retorting section with cowling to direct air flow over the fins and to control shell temperature. Four feeding mechanisms operated hydraulically are utilized on the retort. A common pilot vessel system is employed which actuates the four feeders to discharge and to fill simultaneously. The bottom disengaging section of the 1,000 ton/day retort consists of four slotted cones, the apex of which included angles of about 40°. Products of the shale kiln discharge through these slots and are collected in an annular section surrounding the slotted cones. Solids which may drop through the slots fall down through the liquid seal and are reintroduced through the feeder. Operation of the shale kiln is entirely automatic. A temperature controller actuated by thermocouples located on the shell of the retort maintains the burning section approximately at the tip of the plows of the kiln by control of the feeding mechanism.

Conclusion

This review has attempted to outline the basic considerations in the development of process systems handling moving beds of granular solids. During the past decade immense progress has been made in this field of engineering. It has already led to numerous advancements in the methods of processing available to industry in general. Because of its newness, careful considerations must be carried out in any design or application of these techniques. The ingenuity and versatility available in these various moving bed operations offer challenging prospects for future developments and applications in the process field.

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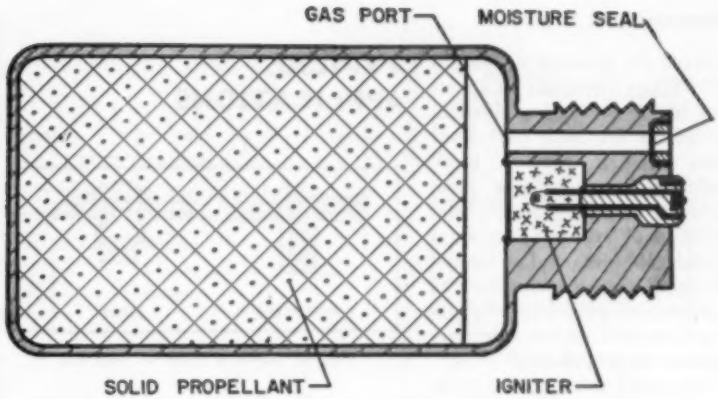

Fig. 9. A typical gas-generator unit.

THE INDUSTRIAL USE OF high-energy materials

C. H. Carlton, F. A. Warren, and J. H. Wiegand | Southwest Research Institute, San Antonio, Texas

There are many substances which, alone or as mixtures, can be placed in the category of high-energy materials. Of these, explosives, propellants, and pyrotechnics form a group whose wide utilization by the Armed Forces is fully appreciated but whose use by industry may not be so fully realized. This paper reviews the industrial use of these materials and discusses possible future applications.

Historically, explosives came into existence around the 13th century with the revelation that a mixture of potassium nitrate, charcoal, and sulfur, now known as black powder, was capable of doing mechanical work. This discovery is recorded by Davis (*1*) as one of the three great discoveries signaling the break-up of the Middle Ages, the other two being printing and the discovery of America. Significant change did not occur in the explosives field until around the middle of the 19th century when nitroglycerin and nitrocellulose were introduced. These discoveries were soon followed by the development of dynamite by Nobel. Colloidal gun cotton was not adopted as a gun propellant by the military until 1900. Other nitrated substances were discovered as time progressed, with TNT being the most powerful explosive in World War I. The past ten years or so have seen the development of a relatively wide variety of these high-energy materials, manufactured under close quality control, and with an equally wide range of performance characteristics so that today there is available a source of power which possesses considerable flexibility and excellent reproducibility.

The high-energy materials being considered in this paper are characterized as either single substances or mixtures of substances which liberate relatively large amounts of energy at relatively rapid rates. A comparison of the relative amount of energy (B.t.u./lb.) contained in several of these materials is shown in Figure 1. The value for fuels (typified by ordinary gasoline) has been corrected for the amount of oxygen required to bring about complete combustion. An arbitrary comparison of the relative rates of energy release (B.t.u./hr.) for these same materials is given in Figure 2.

In addition to the above characteristics, most of these materials contain within themselves all the ingredients needed for their reaction. In the case of liquid propellants, the oxidizer and the fuel components are usually stored separately (e.g., in bipropellant systems) until ready for use. They are then fed to the combustion chamber where they are intimately mixed. Some studies of monopropellant systems, which are essentially ogygen sufficient, have also been made. Whether these substances are explosives, propellants, or pyrotechnics is usually determined (rather arbitrarily in many cases) by the form in which the energy is liberated and by the rate at which it is released. In general, explosives undergo violent chemical reactions with extremely rapid release of energy in the form of heat, gas (i.e., pressure), light, and sound. Propellants on the other hand, although undergoing a similar reaction, do so at a much slower rate. Pyrotechnics are thought of more in terms of the heat and light which they liberate than by the rates of reaction.

These high-energy materials are seen thus to represent one of mankind's most powerful sources of energy in concentrated form. Put to proper use, they can produce work economically by saving time and capital investment and, in many instances, do a better job than many more familiar materials.

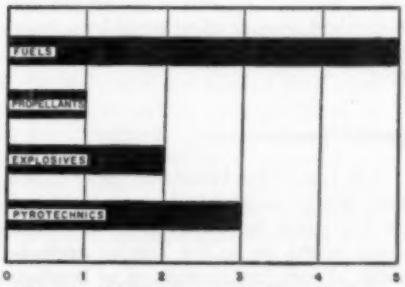

Fig. 1. Relative energy content of high-energy materials (based on propellants = 1).

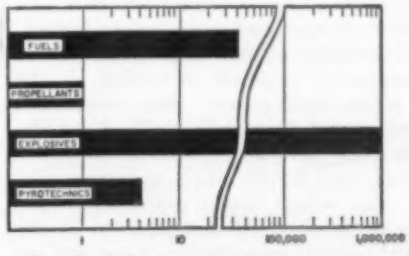

Fig. 2. Relative rate of energy release of high-energy materials (based on propellants = 1).

Major Applications

At the present the greatest utilization of these high-energy materials on a tonnage basis is in the form of explosives. Major applications for such explosives as dynamite, blasting gelatin, black powder, and ammonium nitrate compositions are in mining, construction, and geological exploration. Propellant usage is considerably less and is limited primarily to small-arms ammunition for sport and protective purposes. Apparently data are not available concerning the consumption of propellants.

In 1952 there were some 20,000 regular consumers of commercial explosives who used some 366,000 tons of this material (*2, 3*). This quantity was higher than that produced during World War II years, and the production is still growing as a result of the increase in population, the increased use with the rise in the standard of living, the depletion of rich ore deposits, and the development of new uses for explosives. The consumption of industrial explosives in 1953 was about the same as for 1952. The distribution among consumers is illustrated in Figure 3.

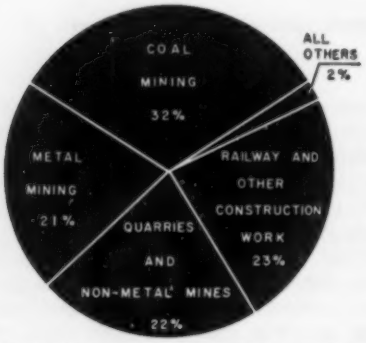

Fig. 3. Consumption of industrial explosives in 1953 (*Bureau of Mines report*).

Because of the depletion of rich ore deposits, the mining industry has had to use increased amounts of explosives to develop new deposits. In so doing, it has become the major consumer of explosives. Coal mining alone in 1952 used approximately 140,000 tons (*2*) whereas all other mining activities collectively consumed an equivalent amount. Illustrative of the large quantities of explosives required in mining, is the largest underground blast on record, which was fired at Leadville, Colorado, in 1933. A total of 56 tons of explosives was used in this single operation (*3*).

The second largest use of explosives is in the construction field, in which the 1952 total consumption amounted to 75,000 tons. When the size of individual construction projects, such as the Panama Canal, Tennessee Valley Authority, and certain hydroelectric plants is considered, this large consumption is not surprising. In the construction of the Panama Canal, the United States Government purchased approximately 30,000 tons of explosives up to the formal opening of the Canal in 1914. The record for a single blast is held by the Tennessee Valley Authority which set off 680 tons of Nitramon, connected with four miles of primacord, near Bristol, on the Virginia-Tennessee line, in 1949. As an example of precision blasting, there is the development of the New York subway system, comprising some 130 miles of tunnel, constructed without interrupting traffic above ground and with few people even aware that the work was in progress.

The remaining uses for explosives accounted for some 6,000 tons in 1952. Of this amount it is believed that the major quantity was used for exploration purposes. The technique of seismic prospecting was first used in 1923 and has been developed with marked success during recent years. This method is used primarily for subsurface mapping in order to locate oil and gas formations. Present expenditures in this country for seismic prospecting are estimated at $300,000,000 a year (*3*); foreign work, most of which is done by American companies, represents another $100,000,000. Although the tonnage quantity of explosives used is small compared to the expenditure total involved, it is difficult to envisage any other method by means of which an equivalent amount of oil could have been located for anywhere near the same cost.

TYPICAL APPLICATIONS

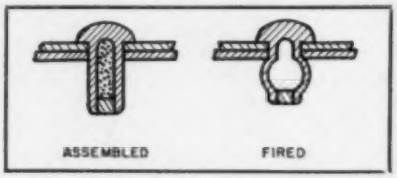

Fig. 4. Explosive rivets as fasteners.

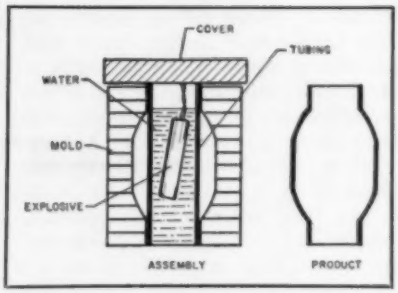

Fig. 5. Metal forming with explosives.

Special Applications

The remaining industrial uses for the high-energy materials being considered in this paper have been separated into what might be called special applications. From the standpoint of tonnage consumed, the utilization is dwarfed by that used in mining, construction, and exploration. In terms of economical aspects, however, it is believed this type of consumption is extremely important as it involves techniques by means of which certain jobs can be accomplished more efficiently, more quickly, and more economically. Here too explosives play a major role, but the use of propellants seems to be increasing. Pyrotechnics are also important, but are used only to a somewhat limited extent.

EXPLOSIVES

Explosives are utilized for the most part in two ways—in controlled detonation devices and, as a modified form of detonation in the shaped charge. An important example of controlled detonation is the explosive rivet (*4, 5*). This application consists of a hollow rivet containing a temperature-sensitive explosive; for example, it could be a mixture of lead azide and tetrazene which ignites at 300° F. These rivets are used for blind fastening in inaccessible places, such as in truck or bus bodies and refrigerator doors. A schematic diagram of an explosive rivet is shown in Figure 4.

The steel industry uses explosives to reduce scrap iron to a size suitable for feeding into blast furnaces (*3*). "Salamanders" and slag pockets in steel furnaces also are blasted free by means of controlled detonations. Explosives are used also to start airplane engines (*4*). An explosive cartridge is inserted in the head of one of the cylinders. On detonation the piston is accelerated, such action starting the whole engine (*4*). The Cordeau-Bickford fuse, consisting of high explosive in a fabric tube, has been used by itself for cutting steel and wood and has been employed also as a high-explosive initiator.

The oil industry finds use for high explosives, although less frequently than before, in oil-well shooting, whereby a large quantity of explosive is detonated at the bottom of an oil well for the purpose of fracturing the formation in an

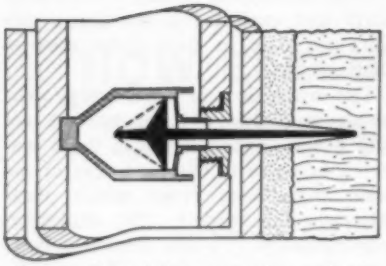

Fig. 6. Shaped-charge gun for perforating oil wells.

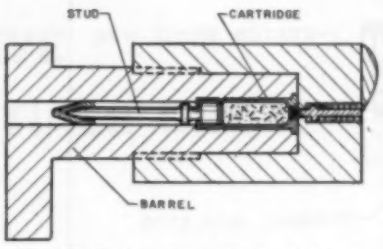

Fig. 7. Section of a typical stud driver.

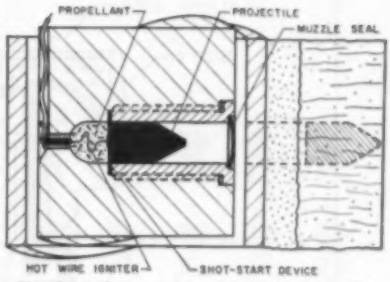

Fig. 8. Bullet gun for perforating oil wells.

attempt to initiate the flow of oil. A more spectacular application consists of the blowing out of oil-well fires by the carefully controlled detonation of explosive charges.

A recent application which illustrates clearly how the ingenious use of explosives can reduce manufacturing costs is the method employed by a fan manufacturer (*6*) in the fabrication of industrial fans. The fan hubs are made by placing a cylindrical monel blank inside a heavy laminated steel die. The assembly is partially filled with water, and a stick of dynamite is then detonated at the water level, neatly forcing the monel metal into the contours of the die in a single operation. This use is illustrated schematically in Figure 5.

The shaped charge, used so widely and satisfactorily by the military services, also has found application in industry. A jet tapper (*3, 7*) is now being marketed for use in tapping open-hearth furnaces as a replacement for the oxyacetylene torch. This tool provides a safe method for the tapping operation inasmuch as personnel are not required at the furnace tap hole when it is being opened. The oil industry uses the shaped charge (Figure 6) extensively for perforating the oil well casing and producing a shallow hole into the formation (*3, 8*).

PROPELLANTS

Propellants are employed in special types of industrial guns in rockets and as controlled gas producers. The rivet gun or stud driver uses a solid propellant charge to drive a rivet or stud into metal, wood, or concrete in place of nails or tamp-ins. Figure 7 shows a sectional view of the stud driver. This device has the advantage of fast operation coupled with the ability to insert studs into material such as concrete without cracking it. The industrial gun (*9*) is a small-scale artillery piece designed to fire a 3-ounce lead projectile at a muzzle velocity of 1,600 ft./sec. This gun is used at present for breaking down clinker rings in cement kilns and for knocking down overhanging ledges in quarries, along railroads, or in other inaccessible places. The oil industry uses a short-barrelled gun firing a special hardened projectile to perforate the casings of oil wells (*10*), an alternative method preferred by some operators over the shaped charge. A sectional view of a typical bullet-type perforating gun is shown in Figure 8.

An early use of the rocket has been in firing life lines from shore to ships in distress. This method has the advantage of firing a projectile at low acceleration and without recoil. Rockets are also used as a research tool for studying the earth's atmosphere. A practical rocket application is illustrated by its use by the farmers of Longkloof, on the eastern cape of South Africa, who used rockets to transmit iodide crystals into thunderheads passing over the valley in order to induce useful rain formation rather than damaging hail. In the aircraft industry the jet-assisted take-off unit (JATO) (*12*) has been utilized where heavy loads are to be lifted off short runways. Both solid and liquid propellant systems are used in rockets, the latter having the advantage of being controllable during burning, whereas the burning pattern of solid propellants is established before firing by the form or granulation of the solid propellant grains used.

Although gas generators (Figure 9) utilize essentially the same propellants as rockets, they do not necessarily have sonic nozzles nor utilize the rocket-propulsion principle, but instead they make use of the expansion characteristics of the gas produced. An example is the chemical gas generator Chemechol for the coal industry (*3*). This apparatus employs reacting chemicals to produce gas pressure inside a tube equipped with a rupture diaphragm at one end. The pressure is released suddenly inside a coal seam, producing a more desirable fracture of the coal than the more violent detonation of an explosive charge. In another application an oil-well service company uses a gas generating charge to induce flow in an oil well (*13*). The gases from the burning propellant charge rise in the well much as in a coffee percolator, forcing oil or other liquids ahead of it. Gas generation is also used in the sealing of perforations in oil-well casings by means of a cement-squeezing operation (*14*). The power for this operation is supplied by the burning of a propellant charge inside the cementing tool.

materials

PYROTECHNICS

Pyrotechnics are utilized for the most part in matches, squibs for igniting fuses, flares, signals, fireworks, and the like. Figure 10 shows the main component of an initiator for gas generators. Signal rockets and flares are used as distress signals by ships, airplanes, motor vehicles, and railroads. The quantity of pyrotechnic material consumed is certainly quite small, but the availability of such distress signals in times of emergency is extremely important. A considerable amount of pyrotechnic material is also consumed annually for firework demonstrations.

Future Applications

In the previous sections the various applications for high-energy materials have been considered in order to establish certain general performance characteristics upon which to base suggestions for future applications. It has already been pointed out that these high-energy materials can, in general, be divided into several classes on the basis

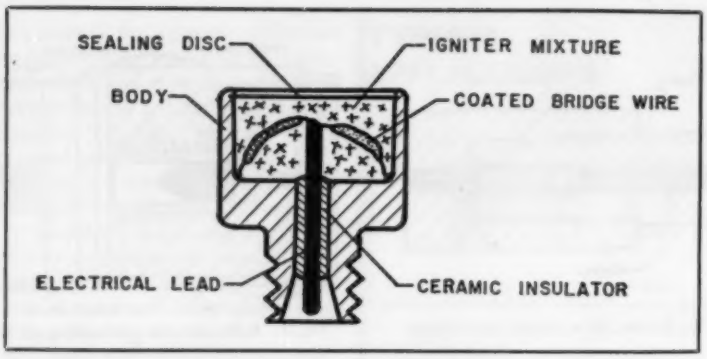

Fig. 10. A typical electrical initiator.

of manner or type of energy liberation, that is, energy in the form of a compressed gas, an explosive energy, as propulsive energy, or as heat, light, or sound. In many instances, the same material can supply energy in several forms, depending on the method of fabrication. What may not be immediately evident is that these materials are no longer unpredictable materials, but are made to extremely close specifications under controlled manufacturing conditions. Consequently their performance permits precise calculation of ultimate effect.

Although explosives appear to have been exploited by industry to a much greater degree than many of the other high-energy materials, there still seems to be room for expansion. Controlled detonation offers a means for producing extremely high pressures of short duration with a small expenditure for capital equipment. A tremendous concentration of energy is developed in the shaped charge in the form of heat and force capable of puncturing extremely thick sections of metal or even concrete. Both principles can be utilized under controlled conditions to provide reproducible, dependable operation. The chief advantages of these systems would seem to lie in the fact that they can be made to function in remote places, can be installed for emergency situations with extremely low maintenance costs, and require only a small space for a large amount of power. It has been suggested that fire chiefs be provided with either shaped-charge or controlled-detonation devices so that they could break down steel doors or other locked sections of buildings in case of an emergency.

The less violent of the high-energy materials, the propellants, offer energy in the form of propulsive energy or compressed gas. The propulsive energy has been harnessed in the form of rockets and JATO's. The possible applications with this form of power seem extremely large. As a source of power to move a stalled object or stop a moving one, to transport an object from one place to another, or as a driving force especially in times of emergency, all appear to be potential uses for propulsive energy. The production of gas at a given pressure and rate can provide a useful source of power. The gas generator utilizing a solid propellant charge is such a device. It can be used to drive a turbine, move a piston, or do a multitude of jobs. From the industrial economics standpoint, this type of energy is attractive because of low initial cost, small-volume requirement, and applicability to remote operation.

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The utilization of high-energy materials by industry is of interest not only to the manufacturer of these materials but also to the producers of the basic ingredients from which these materials are made.* The explosives manufacturers (*1*) use relatively large quantities of nitric and sulfuric acids, glycerin, glycol (and some sugars), phenol, toluene, and other related chemicals. The propellant producers (*1, 12*) utilize many of these same materials and, in addition, cellulose, ammonium and potassium perchlorates, ammonium nitrate, aniline, peroxides, alcohol, hydrazine, and certain rubber and plastic materials. The pyrotechnics manufacturer in turn consumes relatively large amounts of ground metals and inorganic oxidizers in addition to various organic binders.

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HOW EXECUTIVE POTENTIALS GROW

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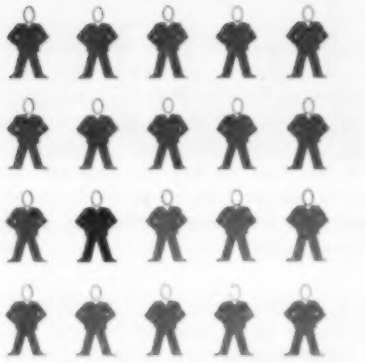

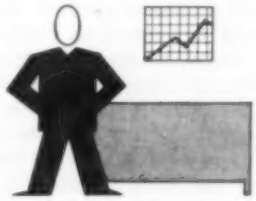

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Too many company presidents may be soothed into hazardous complacency by the existence of a so-called executive training program. Regardless of whether such a training program is installed and run by outside experts or by inside staff specialists, it does not realistically provide replacements for top management at the time when they are urgently needed. There are three possible reasons for this:

1. **Whereas outside experts and inside staff men can do much to help, top management must take a dominant role in grooming its own successors.**
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The one common and outstanding attribute of a potential top policy-making executive is his obvious drive to grow, his eagerness for assuming increasing responsibility, and his unyielding desire for a high level executive position. You cannot give this type of man training in the ordinary way. You can only make available to him what he is eager to take. The means by which executives develop are those in which the stimulus for growing emanates from within the potential executive. He is eager to take and to get all that he can from the well-tried and experienced executive team. He progresses best under the atmosphere of coaching and getting his teeth into real problems pressing for solution.

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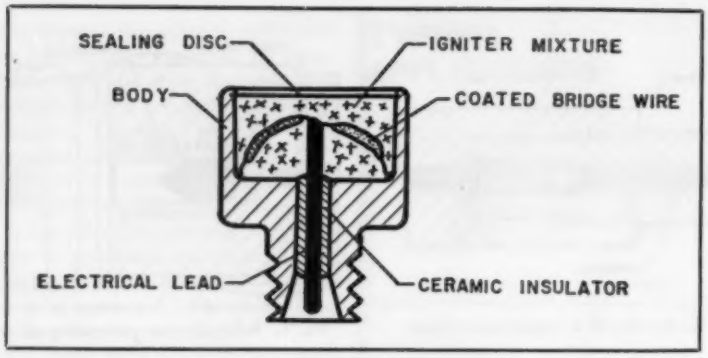
For those who have executive potentiality, a basic structure or schematic outline to facilitate their growth and enable them to take full advantage of opportunities for development or specialized training should be considered. The following outline is merely a guide. It is a pattern for self-reliant development and *learning by doing.* It is an orderly sequence which should contribute most by avoiding doldrums and inactivity of the usual program of executive development or training.

GUIDE FOR INDIVIDUAL DEVELOPMENT

1. EXPERIENCE

There is no practical substitute for experience. Experience means that a man should have a variety of jobs in which he can assume responsibility and be judged by his performance. Merely looking in on the sidelines is not experience. This is chance observation. Real experience is all-inclusive—it means performing specific tasks, succeeding and/or failing, making mistakes and



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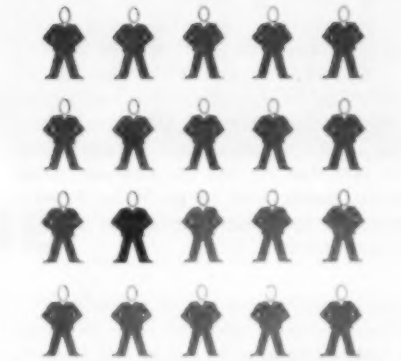
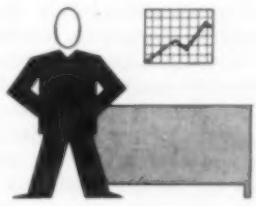
For those who have executive potentiality, a basic structure or schematic outline to facilitate their growth and enable them to take full advantage of opportunities for development or specialized training should be considered. The following outline is merely a guide. It is a pattern for self-reliant development and *learning by doing.* It is an orderly sequence which should contribute most by avoiding doldrums and inactivity of the usual program of executive development or training.





GUIDE FOR INDIVIDUAL DEVELOPMENT

1. EXPERIENCE

There is no practical substitute for experience. Experience means that a man should have a variety of jobs in which he can assume responsibility and be judged by his performance. Merely looking in on the sidelines is not experience. This is chance observation. Real experience is all-inclusive—it means performing specific tasks, succeeding and/or failing, making mistakes and

profiting by them. It establishes the atmosphere and the setting for present top-level executives to do the day-by-day, hour - by - hour, problem - by-problem, difficulty - by - difficulty job of coaching executive potentials. It is a fund of opportunity wherein the executive potential can take full advantage to grow and to demonstrate initiative and creativity. It is important to note that such experience does not foist upon the executive potential a training program. It emphasizes the fact that he has the characteristics which enable him to profit by experience and to utilize it in a way to help himself grow.

2. ORIENTATION

Here the accent is on providing the setting which enables a man to view the horizons, the problems, the policies, the practices, and all the intangibles incident to running an organization. It is the behind-the-scenes atmosphere and the behind-the-scenes insight which a man can obtain only by working closely with major policy-forming executives. Some of this orientation necessarily will involve digging into records, files, and carrying on intensive discussions with key individuals. It also means appropriate interchange and use of experience within the company and with other organizations in related business or industry. But the orientation cannot be undertaken by having a staff man prepare a neatly arranged schedule of activities, lectures, discussions, readings, etc. When a man has made progress in this orientation, he has actually absorbed the spirit and the lifeblood of the organization. It is to him then that the responsibility of carrying on the future organization can be entrusted. He understands the risks. He is familiar with the problems and difficulties and the trials and tribulations involved in making a profit and in perpetuating a successful business enterprise.

3. MOTIVATION AND ASPIRATION

The executive potential must have the attributes which make him want to succeed. He will have an unflinching desire to be successful in a particular organization. He will be determined to go forward in a particular phase of the business or in several phases of it. But his wants and desires cannot be fulfilled unless the incentive is tangible or apparent. A man has to have the insight, the understanding, and the tangible evidence that if he performs, if he disciplines himself, if he learns, if he takes risks, then the incentives and the rewards will be there. This obviously means that policy-forming executives will, for practical purposes, indicate the time and the place for their successors. In keeping with present retirement plans, this is not too difficult a matter provided the incumbent executive faces it in a realistic way. At the age of 55 a major executive should at least have an eye on who may succeed him. Perhaps he will not immediately concentrate on a single individual, but at least he has one or more men identified as potential successors.

4. INFORMATION

This is an area wherein the potential executive will on his own be extending. He will be inquisitive, always searching for facts and information. There is always the possibility that certain types of information may not be available to him. It is up to the present policy-forming executive group to provide such information which is not readily obtained. It is up to the executive potential to decide on the kind of information he needs. It will be only an ordinary task for the policy-forming executive to provide and to point to information which the potential executive should have. Such information may cover the length and breadth of the entire organization in every phase of operation, related or unrelated. There will be obvious circumstances where this extent of "openness" is not practically feasible. But every effort should be made to give the potential executive the information which the present incumbent needs to use in making decisions and in contributing to the formulation of policies.

5. HABITS

The executive potential who is growing will necessarily be acquiring a variety of thinking, planning, deciding, working and living habits. Attitudes, preferences, customs, practices, and strictly emotional reactions will be acquired as habits in association with the present policy-forming executives. The executive potential will be alert to reflecting critically on his customary actions in the broadest sense. He will consciously be avoiding certain pursuits and devoting diligent effort to those which in his own judgment appear essential. He will grow as an executive by critically selective acquiring and styling of desirable habits suited to him for success.

6. SKILLS

The executive potential will necessarily be eager to acquire definite skills. Broadly, these include the application of technical knowledge, an understanding of human relations, and a thinking-coordinating-creative ability. In each of these three broad categories, the executive potential will be devoting personal effort to perfecting the skills required to meet the standards of performance for a particular assignment or job. It will not be generalized or abstract learning. For example, there are specific communications skills, such as reading, conversation, public speaking, and diverse business writing. The executive potential will be consciously improving these skills as he performs tasks assigned to him. It is such skills which contribute much to getting executive work done and to making sound decisions. The various skills may be apparent to the man, but he may need to have them pointed out at some stage in his growth with the company. It is doubtful whether any organization or its policy-forming executives should devote much time-consuming effort to furthering skills of potential executives.

7. TECHNIQUES

Herein are certain procedures, ways of doing, and specialized techniques which executives by experience have found necessary and which have contributed to success of the organization. Some of these techniques are nothing more than an experienced mode of thinking or patterns of action, thinking, or deciding. Others are identified with specific types of creativeness. The extent to which the problems are focused specifically, involving thinking and creativity on the part of the executive potential, may contribute to his growth and development.

8. SPECIALIZED EDUCATION

It may be necessary for some men to acquire specialized knowledge pertaining to certain areas related to the business. This may include such subjects as accounting, production management, costs, quality control, statistical methods, sales management, special phases of management, administration and control, advertising, financial matters, economics or particular sciences related to the business. Education or special formal courses will voluntarily be sought by the desirable potential executive. It will also be helpful if incumbent policy-forming executives merely indicate suggestions to potential executives.

View taken west of the recovery area showing in the right foreground the cumene return still with the other stills in the alkylation area appearing in the right background. In the center background can be seen the two batch stills and to the left the control room, and back of that phenol recovery area stills and acetone recovery area stills can be seen.

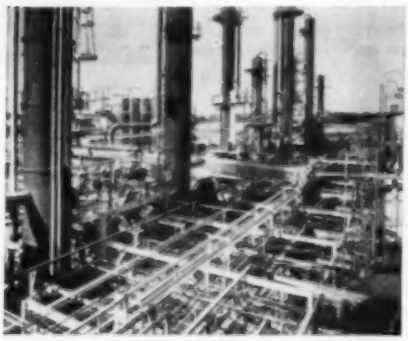
Phenol from cumene plant is put on-stream for first time by Hercules Powder Company, actual developer of the process in this country.

Highly versatile process is basis of new oxychemical plant.

PHENOL FROM CUMENE

After licensing two other companies to build plants based on its process, Hercules Powder recently opened its own phenol from cumene plant at Gibbstown, N. J.

The multi-million dollar plant, designed to produce 26 million pounds of phenol and 16 million pounds of acetone annually, is the largest synthetic phenol plant on the Eastern Seaboard. Although Hercules sees growing market for phenol, anticipates no trouble selling full theoretic output eventually, the economics of the process depends largely on market for high-percentage by-product acetone, and on versatility of the plant.

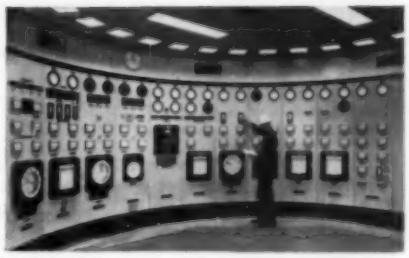


View taken from the top of the Liquid Caustic Storage Tank looking down upon the piping above the recovery area operating alley. In the foreground can be seen pure phenol still column, utility batch still column, and to the right the phenol recovery still column, and in the background to the right acetone recovery area still columns. In the center background can be seen three of the four oxidizers.

Versatility Plus

In the basic process of producing phenol and acetone from cumene, the plant also produces as by-products alpha-methylstyrene, acetophenone, and hydroperoxides.

The same plant is readily capable of producing para-cresol, is being used for this at Hattiesburg, Miss. Now Hercules plans to move its para-cresol production to Gibbstown, expand from 1 million pounds/year to at least 2-2½



million pounds, possibly three or four times that.

Process can also make resorcinol and hydroquinone. Pilot plant work is already underway on these products.

Looked on with highest interest is a new product to replace sulfur and all presently needed boosters and accelerators in the vulcanization of rubber. The product, di-cumyl peroxide, does not discolor or increase opacity of the rubber, is not affected by light. The di-cumyl peroxide will be made at the Gibbstown plant, is already being sold to the polyester manufacturers. Hercules is working on price reductions to bring it within the range of present vulcanizing materials.

Process

Basically, the process involves the alkylation of benzene with propylene to produce cumene. The cumene is then oxidized to cumene hydroperoxide, and the hydroperoxide is cleaved to phenol and acetone. Final step is purification of the cleavage mixture.

A nearly automatic plant, the Gibbstown installation is laid out in the shape of a U, with alkylation done on one leg of the U, oxidation and cleavage on the other, and purification in the base. Entirely open, for safety among other things, the plant is operated from a central control room inside the U, needs only 6 operators during the day, 13 at night including watchmen.

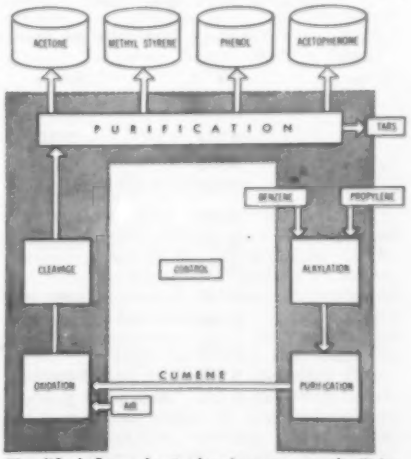
Raw materials are readily available in the area, benzene coming from nearby steel mills, propylene from neighboring Socony refinery.

Production of the new di-cumyl peroxide is done at point after oxidation process and before cleaving.

The Key—Acetone

At present U. S. production capacity of phenol is rated at about 580 million pounds per year, consumption at 460 pounds per year. But the consensus of the industry is that more phenol capacity will be needed in three to five years. Now the Gibbstown plant is producing at about 75% capacity, down to some 50% in certain months, but Hercules has little fear on ultimate market for phenol.

The crux of the economic picture is the acetone. Output of the plant by per cent when operated for phenol is about 100 pounds phenol to 60 pounds acetone and 20 pounds of acetophenone and methyl styrene combined. With such a high percentage of acetone, a drop of a few cents in the price of acetone can cause serious economic problems for the plant. For this reason Hercules is busily investigating all potential products that can be produced by the plant, studying new uses for acetophenone, acetone, resorcinol and hydroquinone, as well as working on potential new vulcanizer. □



Simplified flow sheet showing process facilities as laid out in the shape of a U.

NIONEL REFERENCE SHEET

(Part 3)

W. Z. Friend

International Nickel Company, Inc., New York

LABORATORY CORROSION TESTS DATA

Nitric Acid

Nionel is resistant to nitric acid solutions of practically all concentrations and temperatures. Laboratory tests in boiling 65% nitric acid for five 48-hour test periods (Huey test) show these results:

Huey Test

Corrosion Rate, inch per month

Period 1	Period 2	Period 3	Period 4	Period 5
0.00095	0.00117	0.00185	0.00212	0.00340

In view of the generally useful resistance of the stainless steels in many nitric acid solutions it is probable that application of Nionel will be mostly with mixtures of nitric with other acids such as nitric-sulfuric, nitric-phosphoric, and some nitric-hydrofluoric solutions.

Sulfuric Acid

(Ave. of three 48-hr. tests)

Conc. H_2SO_4 % by wt.	Corrosion Rate, inch per year 176° F.	Boiling
5	0.002	0.022
10	0.017	0.020
20	0.013	0.017
30	0.012	0.015
40	0.010	0.016
50	0.009	0.050
60	0.010	0.10
70	0.013	Excessive
80	0.050	Excessive
90	0.135	Excessive
96	0.030	Excessive

PLANT CORROSION TESTS DATA

Tests Made in Operating Chemical Process Equipment in Plants

Corrosive	Duration of test, days	Temp., ° F	Corrosion Rate, in./yr.
Nitric-hydrofluoric acid solution (12-15% nitric; 3-5% hydrofluoric) in pickling of stainless steel.	108	140	0.010
Crude petroleum containing some H_2S in primary flash tank of petroleum refinery.	73	800–850	0.0007
Straight run gasoline plus water and small amount of hydrochloric acid in top of crude oil still.	176	210–250	0.0003
Synthetic phenol production from cumene:			
a. Immersed in mixture of cumene and lumene hydroxide.	25	175–220	∠0.0001
b. Immersed in mixture of cumene, acetone, phenol and 100 ppm SO_2. Agitation.	16	140–160	0.0007
Paper pulp stock (Kraft) with residual chlorine dioxide bleach, pH 6.5. Immersed in headbox.	14	155	∠0.0001
20% phosphoric acid plus 20% hydrofluoric acid. moving slowly.	13	70–85	0.014
Sodium hydryde descaling process. Typical cycle: 90 min. in NaOH–NaH at 700° F; water quench; 2 min. in 10% sulfuric acid; 7 min. in nitric-hydrofluoric acid pickle; 7 min. in Krupp pickle (nitric-hydrochloric-sulfuric acid). Temp. 120-160° F in acid pickling baths. Duration of test 10 cycles.	–	–	0.0005
96-99% sulfuric acid plus ferric sulfate, ferric chloride saturated with HCl. Immersed in pipe return line from bottom of tower in sulfuric acid drying of HCl. Agitation.	163	75–85	0.0002
1-5% sulfuric acid solution plus vegetable oils, fats and greases. Immersed at outlet of hot acid cooker.	92	220	0.004
5-50% sulfuric acid solution plus fats and oils. Immersed during sulfuric acid washing of fats. Heated with live steam. Agitation.			
a. Top of tank.	40	160–200	0.003
b. Bottom of tank near steam inlet.	40	160–200	0.007
Sulfuric acid treatment of naphthalene using 66° Bé sulfuric acid with some dilution by water wash.	12	200	0.25
57° Bé sulfuric acid in coolers.	22	120–160	0.081
25% sulfuric acid plus castor wax—followed by caustic soda wash. Immersed in fat splitting tank. Agitated with live steam.	25	180–212	0.0009
Sulfur distillation in still.			
a. Liquid.	12	850	0.008
b. Vapor.	12	850	0.028
Tar acids in top of tar still.	188	355	∠0.0001
25% zinc chloride-water solution, pH 4. Immersed in tank during mixing of flux.	56	75–80	0.003

No. 47

candidates for 1956

Below are pictures and brief biographical sketches of candidates for A.I.Ch.E. offices in 1956 as chosen by the Nominating Committee and by petition. Additional details are available from the Secretary's Office on each candidate's education and professional life. Any member who wishes these biographic data need only request them.

Ballots will be mailed by the executive secretary's office in October. All nominations by petition must be received by September 23.

for president

Walter G. Whitman

Professor of chemical engineering and head of department at M.I.T., Conference secretary-general, International Conference on Peaceful Uses of Atomic Energy United Nations, 1955-. Prof. Whitman has had a long history of responsible government and academic positions, ranging from War Production Board to various aspects of Atomic Energy Commission interests. A director of the Institute (1937-39, 1942, 1950-51), has held a number of other important posts. U.N. appointment featured in March (1955) C.E.P.

for vice-president

Earl P. Stevenson

President, Arthur D. Little, Inc., Cambridge, Mass. which he joined as director of research in 1919. Made v.p. 1922, pres. 1935. A business executive of a great breadth of interests and responsibilities, trustee and director of many corporations, foundations, etc. Was a director of the Institute in 1951-53, has been chairman of Patents, member of Housing committees. Has published about 20 papers, many interpreting advances in technology to lay as well as technical groups.

J. Henry Rushton

Professor of chemical engineering at Purdue University, consultant to the A.E.C., Mixing Equipment Co. and others. He has served on a number of Institute committees, has been chairman of Student Chapters, Projects, Future of Institute. Served as director 1952-54. Director, Chicago Section, 1952-55. Has published about 50 papers on chemical engineering subjects, is authority on mixing. Won Wm. H. Walker Award, 1952.

for treasurer

The Nominating Committee appointed in January of each year by Council action, was composed of:

C. G. Kirkbride, chairman
E. B. Chiswell, Jr.
W. A. Cunningham
R. C. Gunness
G. F. Jenkins
G. O. G. Löf
C. W. Nofsinger
T. K. Sherwood
J. S. Walton

Nominations by petition have been received for Roy A. Kinckiner, Donald F. Othmer, and Howard L. Malakoff. As other nominations are sent to the Secretary's office they will be reported in subsequent issues of C.E.P.

Arthur K. Doolittle, vice-president of the Institute this year, informs the Nominating Committee that he could not consider nomination for the office of president for 1956.

George Granger Brown

Consulting chemical engineer, dean, College of Engineering, Univ. of Michigan. A specialist in thermodynamics, Dean Brown has extended his interests and activities into the highest echelons of university, industrial and Institute responsibility. Past-pres. of Institute, was director. Presently treasurer, member of several committees, and representative. Wm. H. Walker Award, 1939. Henry Russel Lecturer (Univ. Mich.), 1955.

for secretary

F. J. Van Antwerpen

Secretary and executive secretary, A.I.Ch.E. 1955-. Publisher and business manager, A.I.Ch.E. publications, 1954-. Mr. Van Antwerpen's election to secretaryship followed a long history of service in Institute activities including many committees and representativeships. In 1947 he joined the Institute staff to found and edit "Chemical Engineering Progress." He is active in developing highest goals of professionalism, engrg. education, uniting of societies, atomic energy application, standards, and others.

candidates

for 1956

for directors

three-year term

NOMINATED BY COMMITTEE

Jack C. Dart

General manager, Chemicals Division, & member of Board of Directors, Houdry Process Corp., Phila., Pa. Mr. Dart has, since 1937 been connected with the petroleum refining industry; with Houdry since 1947. He has been active in Program & Public Relations committees, ch. of Baton Rouge and officer of Philadelphia-Wilmington Local Sections. He is the author of numerous technical papers and patents on petroleum processing subjects.

John J. Healy, Jr.

Asst. to V. P. Research, Development & Engineering, Monsanto, St. Louis. Mr. Healy pursued his industrial career in New England until 1951, when he moved to St. Louis. He has, since 1921, been with Merrimac and Monsanto. He was director of the Institute 1948-50, served with Institute Sections (ch. 1948-50) & Admissions (1944-49) Committees, ch. Boston Section, and representative to Manpower Commission and Industry Relations Committee of ASEE.

Joseph H. Koffolt

Professor of chemical engineering and chairman of Dept. at Ohio State University, Columbus, O. Dr. Koffolt served in various capacities in industry before affiliating with the University in 1929. Consultant to gov. and several industrial firms. Has held all offices with Central Ohio Section, 1937-. Has been member Institute Sections, Membership and Equipment Testing Procedures (distillation) Committees. Dr. Koffolt has published over 40 technical papers.

Jerry McAfee

Vice-president & assoc. director, Gulf Research & Development Co., Pittsburgh, Pa. Dr. McAfee entered petroleum refining research in 1940, and joined Gulf Oil in 1945. He is member of the Housing Committee and is retiring chairman of the Pittsburgh Local Section. He is vice-chairman of the General Committee for Pittsburgh meeting (1956). Dr. McAfee has authored articles on petroleum processes, and has several patents in the same field.

W. R. Marshall, Jr.

Professor of chemical engineering, assoc. dean College of Engrg.; assoc. dir. Eng. Exper. Sta., Univ. of Wisc. Dr. Marshall spent several years with DuPont before joining the University in 1948. He is a consultant to industry on atomization, drying, heat and mass transfer. Active in Equip. Testing Proc. (ch. 1953-), Awards & Program Committees. Institute Lecture 1952, is inspector of curricula for Accrediting Comm. Wm. H. Walker Award, 1953.

Charles W. Nofsinger

President, The C. W. Nofsinger Co., Kansas City, Mo. Consulting engineer to the petroleum, chemical & petrochemical fields. Mr. Nofsinger entered industry in 1922. Presently member Technical Advis. Comm. of Fractionation Research, Inc. 1952-date. Original promoter and first chairman, Kansas City Section (1950). Is active in local committee work, and is the author of a number of papers on petroleum subjects.

Monroe E. Spaght

Executive vice president, Shell Oil Company, New York. Dr. Spaght joined Shell in 1933. After serving with two technical missions in Germany and Japan at end of war, became v.p. of Shell Development (1946), pres. (1949). A widely experienced business executive, Dr. Spaght is a director or trustee of several corporations and Stanford Research Institute. He is a member of the Advisory Council of the Dept. of Chemical Engineering, Princeton University.

Fabian Bachrach

Charles A. Stokes

Director of Research & Development, Godfrey L. Cabot, Inc., Cambridge, Mass. Vice pres. & director, Petrocarb Equipment, Inc. Dr. Stokes remained a staff member at M.I.T. until 1945, consulting in meantime with various firms, including Cabot, with whom he joined in 1944. Dr. Stokes was Kingfish (ch.) of Ichthyologists (Boston Section) 1951-52, and member of executive committee 1950-53. He has published a number of papers on chemical engineering and economics.

NOMINATED BY PETITION

Roy A. Kinckiner

Deputy director, Engrg. Research Lab., Engrg. Dept. DuPont, Wilmington, Del. Mr. Kinckiner joined DuPont in 1924, with whom he has served in various production, development and consulting capacities. He has been active in Research, Program, & Program Fundamentals (ch. 1954-) Comm. In the Phila.-Wilmington Section, he has been chairman of a large number of committees; is presently chairman of Nominating; member Executive Committees of that section.

Howard L. Malakoff

Technical manager, Petroleum Chemicals, Inc., New York. Dr. Malakoff had background of teaching prior to entering petroleum industry in 1943, with Cities Service. He has held several posts in Oklahoma and New York Local Sections, and has been a member of the Program & Institute Sections Committees; is chairman of the Research Committees. He was general chairman of the New York annual meeting, 1954.

Donald F. Othmer

Head, Department of Chemical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. Before joining Brooklyn Poly in 1932, Dr. Othmer was with Eastman Kodak and Tennessee Eastman. He was chairman of the New York Section in 1944, ch. of the Technical Program Comm. for the New York national meeting in 1948, and has served on various committees. His name has appeared on nearly 200 technical papers, and he has 75 patents.

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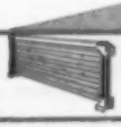
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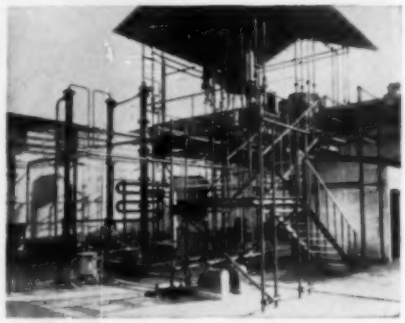
Challenging acetylene as raw material for perchloroethylene, is a relative newcomer—the light hydrocarbons.

Perchloroethylene will be the major product of a new plant being designed and engineered in France for Pechiney, one of France's principal chemical manufacturers, by Scientific Design Co., Inc., New York. Main feature of the plant is the fact that it will be based on the direct chlorination of ethane, methane, or propane.

The new method appears to have some definite advantages, provided its by-product HCl can be disposed of profitably. At Pechiney, the second direct chlorination plant built by Scientific Design, HCL will be used in the production of vinyl chloride.



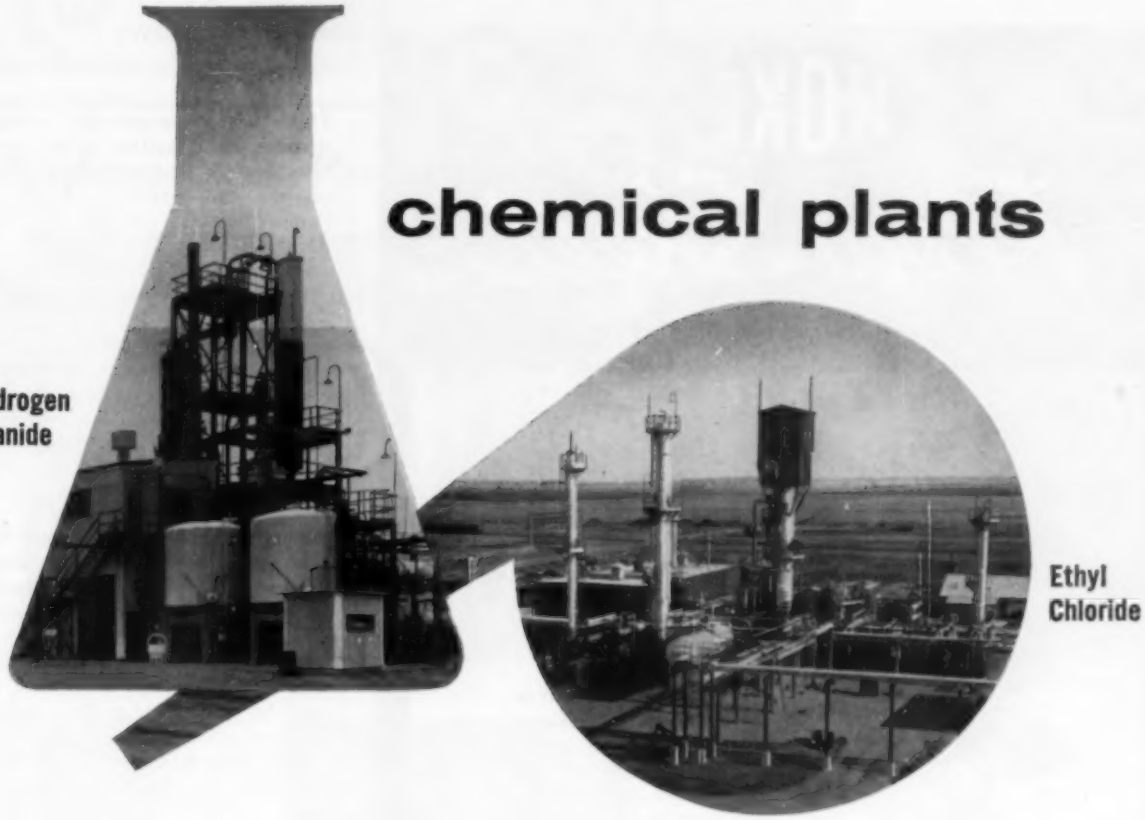
According to Scientific Design, the principal advantage of the direct chlorination method is economic.

The second advantage claimed for the direct process by Scientific Design is a one step to four step production ratio. Four steps are needed in the acetylene process, one step in the direct process. □

Move of New York office of the Pfaudler Company, Rochester, N. Y., under the direction of J. J. Hickey, relocates the office at 33 Newark Street, Hoboken, N. J. A. Gusmer, Inc., sales representatives for Pfaudler's Schock-Gusmer Division, is also located at the new address. The office will continue to serve New York City, Southeastern New York, and Northern New Jersey. □

Ferric chloride smoke at the Hooker Electrochemical Company, Montague, Michigan, plant, caused excitement in that community recently.

The accident occurred while cutting in a chlorine cooler which had just been retubed. Hooker executives believe that some foreign substance, possibly oil, in the tubing caused local overheating and a chemical reaction forming ferric chloride. Melting of the very hot pipe released heavy, brown ferric chloride smoke. □



chemical plants

by FOSTER WHEELER

Process design is the most important engineering function in the building of chemical plants,—in many cases the design data are of a strictly confidential nature, having to do with unusual physical-chemical characteristics of charge, products and intermediates.

Foster Wheeler has completed a number of chemical plant installations in which the final process design was the collaborative product of the client's basic design and Foster Wheeler's cumulative design experience in many industries.

After the process design has been approved, Foster Wheeler specialists take over the detailed operations of engineering, procurement, fabrication and, finally, the construction of the complete chemical process plant.

Experience proves that time and money are saved when the entire project is one contractor's undivided responsibility. *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

FOSTER FW WHEELER

LONDON NEW YORK PARIS ST. CATHARINES, ONT.

NEW DEVELOPMENTS

HOKE
Flow Sheet
Hoke reports on fluid control

THREE RING PERFORMERS

...the O-ring stem seal is one of the special features that make Hoke valves star performers in the fluid control field. Hoke needle, toggle and metering valves are designed with Hycar® O-rings because of this kind of performance:

...they seal leak-tight (these valves will pass high vacuum tests right off the production line!)...they stay leak-tight, you can forget about periodic packing adjustments...and they offer finger-tip control with no packing friction or binding.

Hoke pioneered the O-ring in small valve applications and you'll benefit from this engineering leadership in using Hoke valves on your test equipment, in the laboratory or for instrument air lines.

May we send you catalog information on these three ring* performers?

*(O-rings, that is)

HOKE
HOKE INCORPORATED
Fluid Control Specialists
143 S. DEAN STREET, ENGLEWOOD, N. J.

INDUSTRIAL NEWS

The first completely integrated chromic acid facility in mid-America, a new installation for producing the acid was put into operation recently at the Painesville (O.) Works of Diamond Alkali Company.

Produced from African-imported chrome ore, chromic acid finds broad industrial application. In addition to the manufacture of paint pigments and chromium plating a diverse range of metal products, it is used in making oxidizing agents for drugs and pharmaceuticals, in processing edible oils, and in producing catalysts for petroleum refining. □

A specially designed system for recovering light oil from coke oven gas has increased recovery more than 10% at the Midland, Pennsylvania, works of Crucible Steel Company. The new system, designed by Rust Engineering, uses only one of the two absorption towers used by Crucible for the conventional recovery process.

The claim, based on the first month's operation of the new system, gives credit mainly to the conversion of one of the towers to a spray type absorber instead of the previous packed type. □

Construction of a polyvinyl alcohol plant is in the works for The American Aniline & Extract Co., Inc., of Philadelphia, Pa. The plant will be built adjacent to the Air Reduction plants at Calvert City, Kentucky, and American Aniline will receive a basic material, vinyl acetate monomer, by pipeline from an Air Reduction plant now being built.

The Air Reduction monomer plant, to be completed in the first part of 1956, will produce 30,000,000 pounds annually and will receive acetylene, an important basic material in the manufacture of vinyl acetate monomer, by pipeline from Airco's National Carbide calcium carbide and acetylene generating plant, also located at Calvert City. □

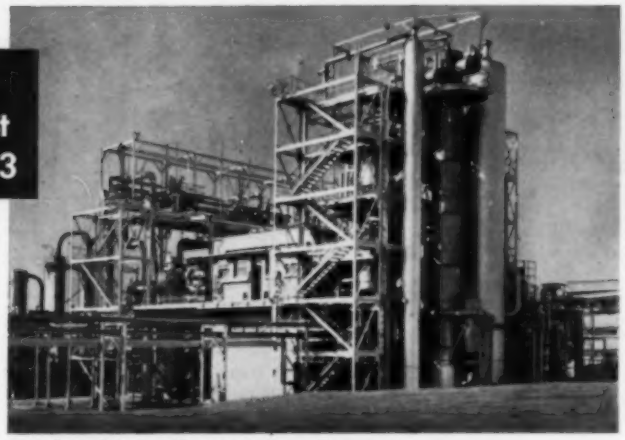
Comparative advantages of Wolverine Tube's integral finned condenser tube, "Wolverine Trufin" was the subject of a two-day seminar conducted in Philadelphia by D. L. Katz, chemical engineering professor, Univ. of Michigan, and recognized authority in the field of heat transfer. □

Descaling with citric acid is the latest method for controlling scaling and maintaining indefinite production in sea water evaporators. Tests made by the Corps of Engineers show that the use of citric acid can increase production twenty times, allow runs up to 10,000 hours without descaling. □

NEW DEVELOPMENTS

3rd Ethylene Oxide Plant To Use SD's Direct Oxidation Process

First Plant 1953



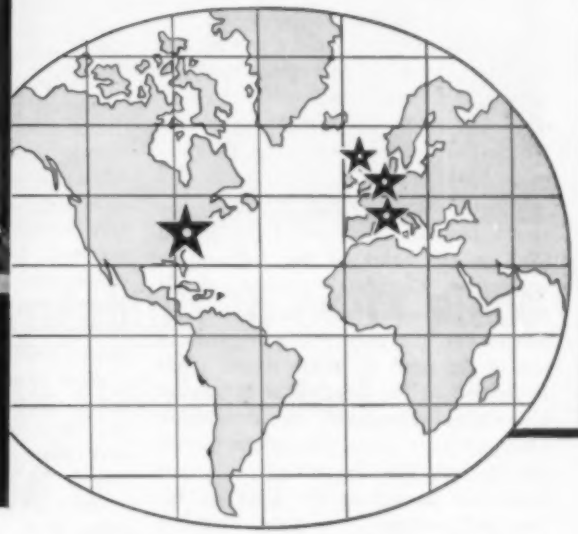
Naphtachimie Plant Lavera, France

Third Plant 1956

Societé Chimique des Derives du Petrole Antwerp, Belgium

"We knew from our laboratory work in America that ethylene oxide could be produced at a lower cost by our direct oxidation process. Our pilot plant work in England proved it," says Dr. Robert Egbert, SD's Vice President of Engineering.

Dr. Philip Newman, SD's European Representative, says, "Our transatlantic experience in adapting standards of various countries to SD's process resulted in greater flexibility of design, as well as continued improvement of the process."



SD's "International Exchange" Pays Off

So far the payoffs have been in Lavera, France, and the United States. Next year SD crosses the Atlantic again for Societé Chimique des Derives du Petrole's new ethylene oxide and ethylene glycol plants in Antwerp, Belgium.

The less expensive direct oxidation process used in these ethylene oxide plants was developed in SD's American headquarters laboratories and put in pilot plant operation in England.

Naturally, there were many problems in "translating" data—both from pilot plant to commercial production and from foreign engineering practices to American standards. SD's international experience in ethylene oxide also provided the background necessary to solve these problems of "translation" in chloromethanes, citric acid and maleic anhydride processes.

Today, American companies can take advantage of the continued "international improvement" of SD's lower cost process of direct oxidation of ethylene.

On this or any other organic chemical plant design problem, SD's services are available to you on a confidential basis. In new plant construction or the revamping of existing facilities to increase production efficiencies, you will profit by utilizing SD's specialized experience in organic chemicals plant design.

SCIENTIFIC DESIGN COMPANY, INC.

Executive Offices:
Two Park Avenue
New York 16, N. Y.
Engineering Offices:
Jersey City, New Jersey

Preview at A.I.Ch.E. meeting, September 25-28 at . . .

LAKE PLACID

W. J. Farrisee, Jr.

Behr-Manning, division Norton Co.

If your summer has been as hectic as ours, three or more days of utter luxury in the midst of September mellowed woods and lakes—all the outdoor activity you want or just taking-it-easy—should sound just right. Add an easy-going conference bringing together top men in chemical engineering management to lead discussions on trends and managerial problems in the process industries. Should be important to anyone who *is* or *thinks* he will be in management—and that's about everyone. Sounds like the perfect way to close out a busy summer.

Where? Lake Placid, N. Y., at the world famous, luxurious Lake Placid Club in the heart of the Adirondack wilderness. Completely remote and yet readily reached by train, bus, airline, or private car, the comfortable elegance of one of the most elaborate resort hotels is nestled at the edge of a turquoise-blue lake, surrounded by mountains. Changed little since Champlain battled the Iroquois (not far away) . . . and Burgoyne passed to the East on his way to Saratoga . . . Lake Placid is the ideal spot to relax and muse about tomorrow's problems of management against a timeless historic background. Occasion for your visit: National A.I.Ch.E. meeting, September 26-28.

Sixteen miles of mountain lake beckon at the Club's front door for swimming, boating, fishing, or just plain looking

—and no plant tours this time, thank you.

For the take-it-easiers—a spacious terrace, long hours with friends and a glass or two on the club's lawn under the trees, two cocktail lounges for indoorsmen, woods for walking, the lake to drift over, the informal beauty of the Club itself, and a library of 10,000 volumes—near the bar, of course.

For those with energy left after the summer (and please do save a little)—forty miles of wilderness bridle paths in the pine and oak forests (just imagine the crunching sound of hooves on the pine needles), gentle but spirited saddle horses for all riders from the tyro through the equestrian, 12 hard-surfaced tennis courts, two 18-hole championship golf courses (bring the clubs for a tournament), and even Mt. Marcy's 5,000-odd feet to hike up if you're really ambitious.

Note to wives: Perhaps you too can use a summer-end vacation, so make up *his* mind to bring *you* along—at our last resort meeting ladies made up one-fourth the total attendance!

We'll all get acquainted at the Sunday evening cocktail party—come hungry, there'll be a buffet afterwards.

For sightseers there are three planned trips. One is to Ausable Chasm, one of the scenic wonders of the United States. Then there's the never-to-be-forgotten drive up Whiteface Mountain where you can see the entire Adirondack chain, down East to Vermont, and all the way up into Canada. And there's a cruise around Lake Placid itself—if this doesn't make an indelible impression, nothing will!

Top People

Keynote of the conference sessions is the management function in the process industries. Top men from many of the leading companies will be there to talk about community relations and other aspects of company social responsibilities management men must deal with. With the results of the Geneva Conference in, nuclear executives will be in a good position to conduct their session on costs, management, organization, and opportunity in the growing atomic energy industry.

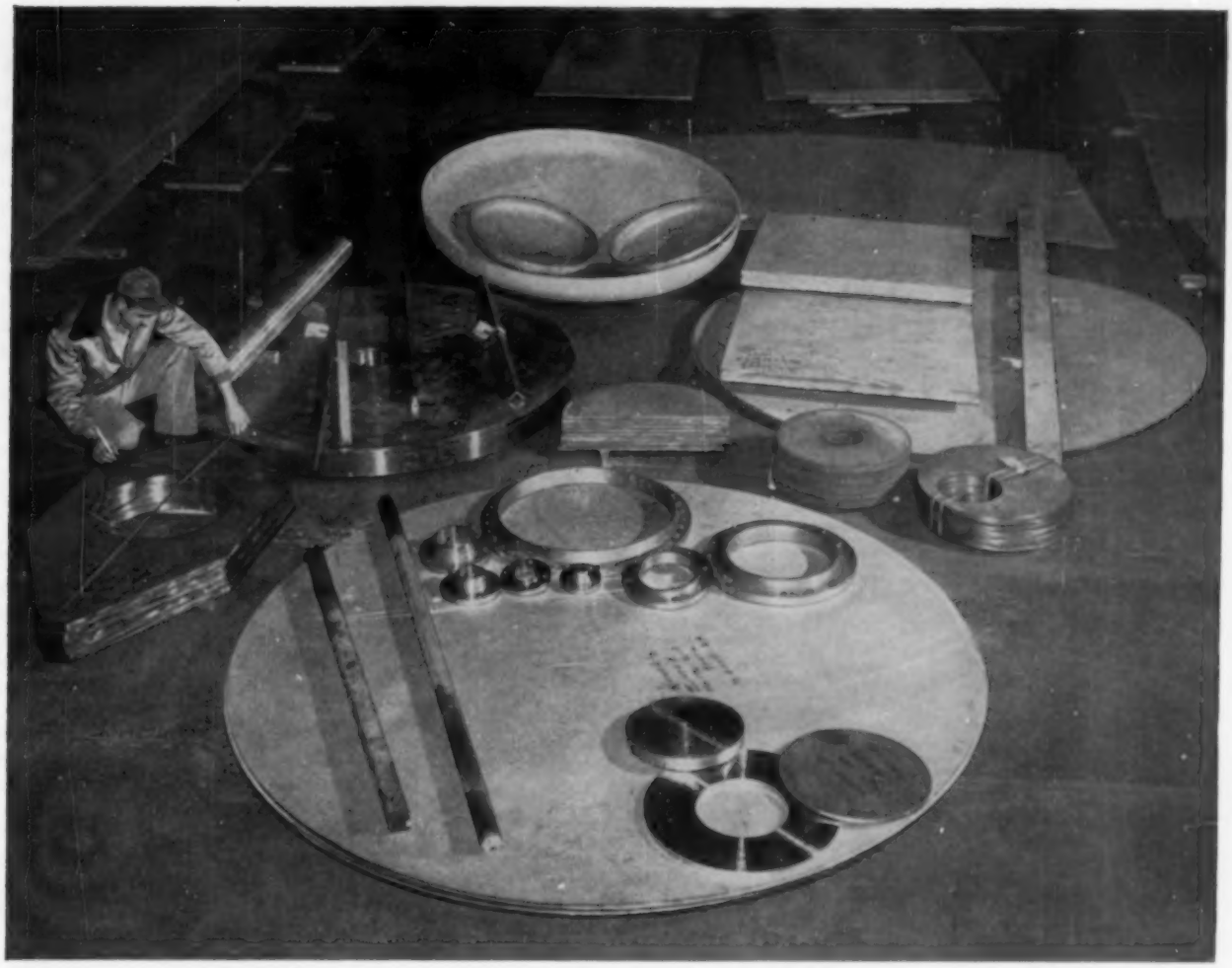
With growing realization of the importance of industrial management taking an interest in the training of fledgling engineers even before they enter industry, a leading educator will present the more progressive views held today on university training of the chemical engineer. Sure to stimulate discussion, tell what future engineers will be like, where they will go, what can be done to get the kind of men needed in industry.

Integration in the oil and chemical industries as a booster for growth, affects all engineers every day, and the conference will get the views of men who have been leading in this development, hear what it has done, where it is going. Bonus for technical interest: A discussion of the revolutionary effect new prime movers may have in the chemical industry.

A banquet and business luncheon fill out the business side of the program as management leaders consider the future on an informal basis over good food. Sport jackets and cocktail dresses will be the most formal wear anybody will bother with.

Relax, Think Clear, Leave Inspired

Plan to come on Friday and stay through the next Sunday. For a top-level conference in a perfect September climate, relaxation in comfort, plenty of outdoor recreation or just taking-it-easy, we think the Lake Placid Club is the perfect spot.



Delivery when promised . . . dependability in every piece . . . and economically produced in stainless steel

on Carlson Order No. 17656

Not every shipment is as diversified as GOC 17656 but it illustrates the typical all-around service in stainless steel available from G. O. Carlson, Inc.

There are plates, heads, rings, circles, flanges, bars and rounds—all stainless steel to chemical industry standards—all made to match the specifications on the customer's blueprint. It took special equipment to make up this order—equipment designed and built by Carlson engineers who work *exclusively* in stainless.

This equipment in the hands of Carlson specialists *lowers* costs. You pay no freight on material you can't use and you save man-hours in easier fit-up, because the material is ready for fabrication when you get it.

When you order your stainless steel from G. O. Carlson, Inc. you can be sure of three things: (1) it is economically produced from the highest quality material; (2) it is cut to your specifications; (3) it is shipped on time. Write *right now* for complete information.

Stainless Steels Exclusively

G. O. CARLSON, INC.

THORNDALE, PENNSYLVANIA

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District Sales Offices in Principal Cities

Why is this wire wiser?

Wiser and better because of a special rubber covering compound employing a **PANAREZ** hydrocarbon resin.

In GRS electrical wire covering applications, **PANAREZ** resins produce stocks which are economical, smooth, glossy, easy processing and fast extruding. They provide excellent color and color stability. They have low specific gravity. They enhance such properties as tensile strength, elongation, tear resistance, abrasion resistance, electrical characteristics and aging qualities.

Applied in many ways in the compounding of synthetic rubbers, **PANAREZ** resins are helping produce better products, *and at the same time effect decided economies.*

Whether your business has to do with wire, shoe soles, belting, floor tile, hose, insulators or some other products, we welcome the opportunity to work confidentially with you on your particular problem. For full information write or wire Dept. CE.

PANAREZ

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555 FIFTH AVENUE, NEW YORK 17, N.Y.

PANAREZ Hydrocarbon resins

PANAPOL Hydrocarbon drying oils

PANASOL Aromatic solvents

INDUSTRIAL NEWS

Incorporating new and radical designs in both equipment and plant construction, **a new soybean processing plant** of Central Soya, Fort Wayne, Indiana, went on stream recently at Chattanooga, Tenn.

Heart of the four-story solvent extraction building is an 850-ton/day Blaw-Knox Rotocel extractor which puts the soybean flakes through seven stages of percolation using hexane as the solvent for the oil extraction.

Feature of the new plant is its "brain" —a master graphic control panel located in a pressurized control room. This fresh-air pressurized room is the only enclosed part of the installation, the rest of the plant being open for maximum safety. □

New multi-million-dollar facilities for the production of plastic for safety glass interlayer will be constructed at Trenton, Mich., by Monsanto Chemical Company's Plastics Division and Shawinigan Resins Corporation.

Shawinigan, an associate company of Monsanto, will construct facilities at Trenton to manufacture Butvar, the polyvinyl resin base material. Monsanto's Plastics Division will construct separate facilities there for converting the Butvar into Saflex sheeting for safety glass manufacturers. The new facilities, expected to be completed during the last quarter of 1956, will double existing capacity for the safety glass interlayer. □

Use of a number of German chemical processes in American plants is the aim of a recent agreement between Arthur G. McKee & Company, Cleveland, and The Uhde Corporation, New York, a subsidiary of Friedrich Uhde, G.m.b.H., Dortmund, Germany.

Heretofore not widely available to U. S. builders of chemical plants, the processes include such products as ammonia and related nitrogen products, carbon bisulfide, formaldehyde, methanol, calcium cyanamide, magnesium metal, polystyrene, and sulfur recovery. □

More low-pressure polyethylene is on the way (Trends, *CEP*, June 1955). Du Pont is building a new pilot plant at its Sabine River Works, near Orange, Texas, to produce the rapidly growing low-pressure produced, rigid type resin.

The Du Pont process will be another licensed under the patents of Karl Zeigler, and the new plant is expected to be completed by early fall.

The new resin will be number 20 in the list of different types of polyethylene produced by Du Pont. □

Finger-Tip Operation at 30,000 p.s.i.?

Of Course... With This Autoclave Valve

Another example of the continuous AE effort to improve the operation of high pressure equipment . . . .

Simplicity of AE design combines with rugged, precision construction to give you a 30,000 p.s.i. valve with "Finger Tip" ease of operation. This AE valve is widely used for reactions at all pressures up to and including 30,000 p.s.i. The gland nut is made of aluminum bronze which, of course, has a low coefficient of friction. Other materials can be furnished if desired. All threads in the stem and gland nuts are up above the packing—thus protected from material passing through the valve. Standard packing is Teflon but other materials are available—for example, a special high temperature packing for temperatures up to 1000°F. The locking device is of non-rusting, stainless steel. Bulletin 555 gives further detailed information. Write for it.

SPECIALISTS IN

LABORATORY AND PILOT PLANT HIGH PRESSURE EQUIPMENT

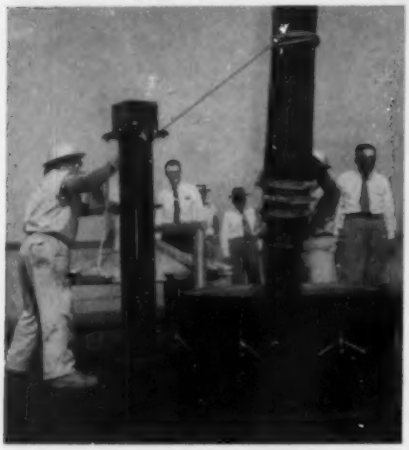
AUTOCLAVE ENGINEERS, INC.

860 EAST 19TH ST. • ERIE, PENNSYLVANIA

Largest tall oil fractionating still in the world is now on stream at Panama City, Fla., for Arizona Chemical Company, the nation's leading producer of tall oil products, jointly owned by American Cyanamid Company and International Paper Company.

The Panama City plant enlargement increases Arizona's production capacity for fractionated tall oil products to 2½ times its former capacity. The expansion was necessitated by increasing demand for the highly fractionated products which Arizona produces for the surface-coating, paint, varnish, soap and similar industries.

Crude tall oil, a mixture of rosin and fatty acids, is obtained from the by-product liquors of southern sulfate paper mills, and its use has grown during the last ten years to the point where tall oil stands third in volume among the inedible fats and oils consumed in industry. □



Sulfur now being shipped as a liquid long distance on special barges, is the news from Freeport Sulphur Company. The advantages are obvious.

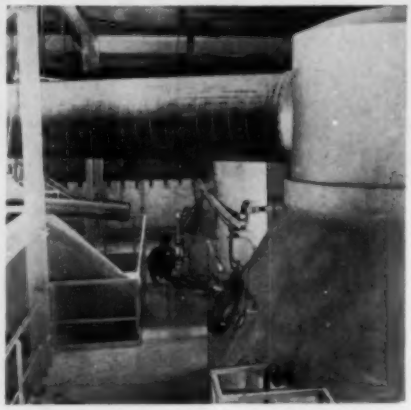
Piped into barges in the same liquid state in which it is mined—instead of being cooled, solidified and shipped in solid chunks—dust loss of sulphur is prevented, moisture is avoided, contamination is reduced, and re-melting at the consumption point is eliminated.

Three barges, built by Ingalls Shipbuilding Corporation and operated by Coyle Lines, Inc., will each take 2,500 tons of melted sulphur 1,100 miles up the Mississippi in 8 days.

Each barge is insulated with four-inch foam glass, is equipped with boilers and heating coils to maintain a minimum temperature of 260 degrees F., 20 degrees above the melting point of sulphur. □

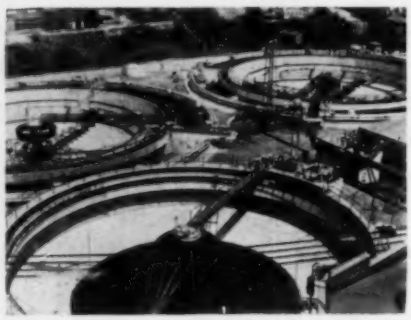
Problems of maintaining precise temperatures in a vacuum-evaporation salt manufacturing process have been solved by the International Salt Co., Inc., through the use of cellular glass insulation on evaporator tanks and steam piping.

The vacuum evaporation process at International uses four evaporator units at the company's Watkins Glen, N. Y., plant. These units handle more than 12,000 gallons of brine per minute and produce 2.6 pounds of salt for every 10.0 pounds of brine.



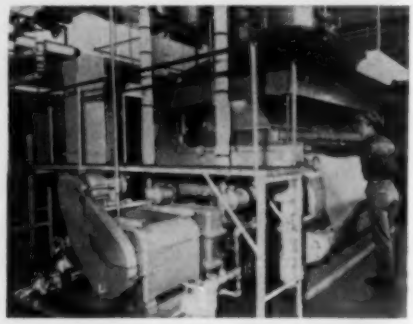
Two-inch thick "Foamglas" blocks, a product of Pittsburgh Corning Corporation, were pre-cut in proper size to fit the lines, some of which are 40 inches in diameter. This, plus the rigidity of the material, makes it possible to remove the insulation while the line is being shifted and to replace the same blocks after the line is reconnected. □

Shown in final stages of construction, the new, $2 million waste treatment plant at the Covington, Virginia, mill of West Virginia Pulp and Paper Company is now completed and ready for initial operation. Using the familiar activated sludge process, BOD of the



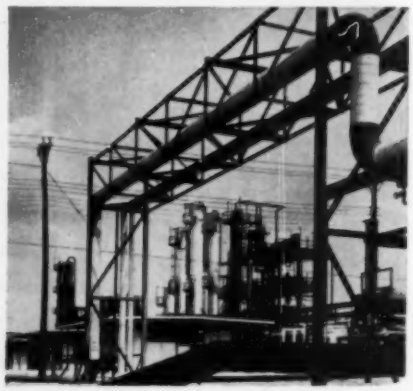
mill effluent will be reduced 80 to 90% before being discharged into the nearby Jackson River. Pulping wastes, after settling in a 100-ft. Dorr Clarifier (foreground), will be combined with clear bleach wastes and the mixture aerated and settled in two 175-ft. Currie Claraetors (background). □

Production of flaked apple pectins has been achieved by the **introduction of continuous and fully mechanized drum-drying equipment** at National Fruit Product Company's Martinsburg, W. Va., plant.



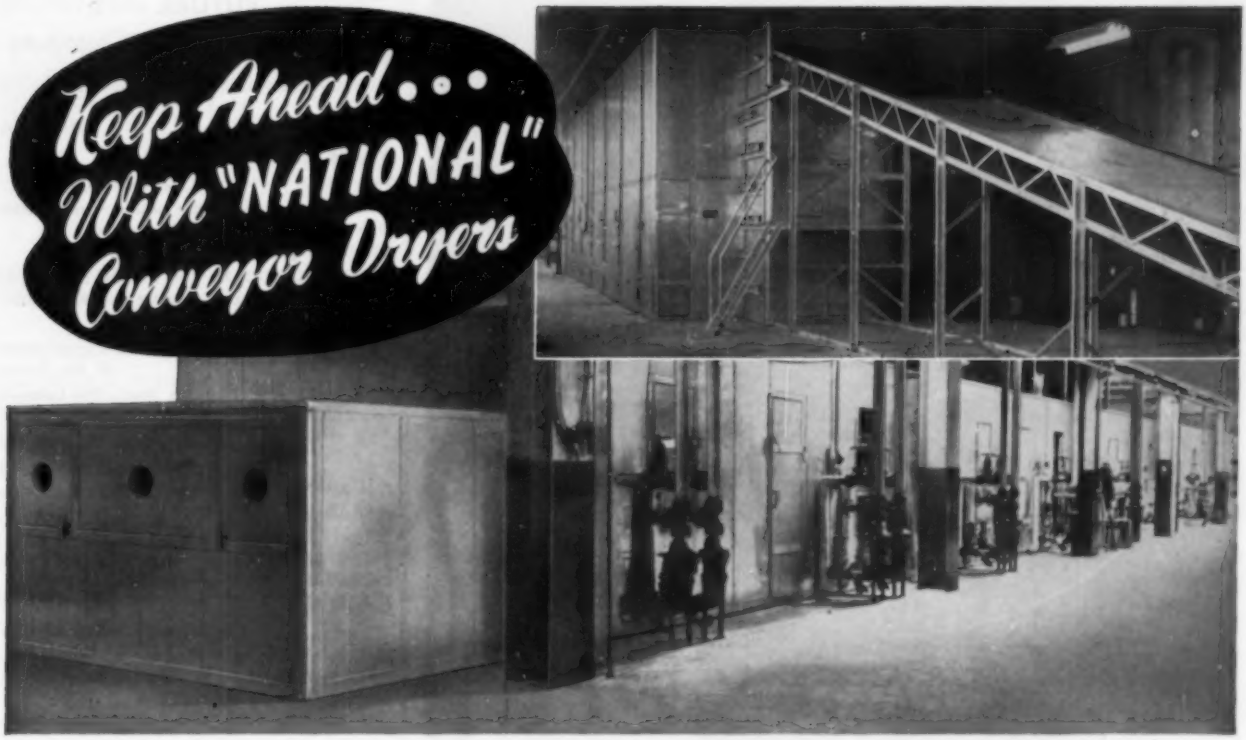
In addition, production capacity was doubled by use of the Blaw-Knox drying equipment, costs were lowered, power requirements became 40% less than for the former batch process, and man-power and space requirements were reduced. In making the change the company also found a means of eliminating one step in the production of pectin. □

New synthetic glycerine plant is expected to be in production at Dow's Texas Division facilities at Velasco late this summer. Utilizing the company's own process, it has a rated capacity of 36,000,000 pounds per year.



The plant will be the second synthetic unit in the world producing on a commercial scale. Glycerine will fit naturally into Dow's broad pattern of products derived from the basic raw materials, liquified petroleum gas and brine. Dow decided to enter glycerine production as a result of increasing demand for the synthetic product. While glycerine has been available for more than a century as a by-product of the soap industry, the mounting popularity of the new synthetic detergents has changed the supply picture—detergents yield no glycerine. □

Keep Ahead... With "NATIONAL" Conveyor Dryers



You can stay in the lead . . . with faster production, lower operating costs and improved product . . . through operation of "NATIONAL" Conveyor Dryers . . . the ultimate in modern Dryer design and efficiency. Pictured above: Upper, large Multiple-Unit, Multiple-Apron dryer; lower, fourteen-section Multiple-Unit Single-Apron machine.

NEW "P-4" CONSTRUCTION

"P-4" Construction means a precision-built, prefabricated, truss-type structure, providing a new measure of strength, rigidity and durability. Advantages to the customer are obvious: Longer service life for the Dryer; smoother operation; freer access for cleaning and maintenance; and reduction of installation time in the customer's plant of as much as 50%. Another important feature of "P-4" Truss Type Construction is that the special method of attaching the panels meets all Underwriter's Codes covering explosion hazards.

IMPROVED HOUSING PANELS

The new insulated panels (Patented and Patents Pending) used for the housing are larger, stronger, more rigid, and, with their 4" insulation, provide greater protection against heat loss. They are of trussed-and-tensioned, non-through-metal construction and incorporate expansion-contraction compensation.

IMPROVED AIR DISTRIBUTION AND CONTROL

The exceptionally high drying speed of "NATIONAL" Dryers results from a combination of adjustable fan power and a unique air distribution system, controlled to assure equal volume of air to the entire run. There is no "shading"—no uneven drying. This arrangement permits drying at consistently higher speeds than those previously permissible. Patented Indexing Orifices, Turning Vanes and other devices and arrangements assure unequalled versatility and precision in air distribution and control.

SUPER-POWER FANS

"NATIONAL" has developed the adjustable-pitch principle into its axial-flow fans which provides far greater operating potentials than heretofore used in any drying machinery. Greater speeds and volume of air can now be employed and adjusted to the specific requirements of the drying operation. The new fan construction includes special alloyed metals fabricated by an improved welding technique. The Fan mountings, insulation and lubricating systems have also been redesigned to provide improved smoothness of operation and virtually no maintenance.

• • •

Other features of "NATIONAL" Conveyor Dryers include continuous hopper feeds; automatic leveler to conveyor belt; pressure extraction and heating for pre-drying.

Write for Complete Information

THE NATIONAL DRYING MACHINERY CO.
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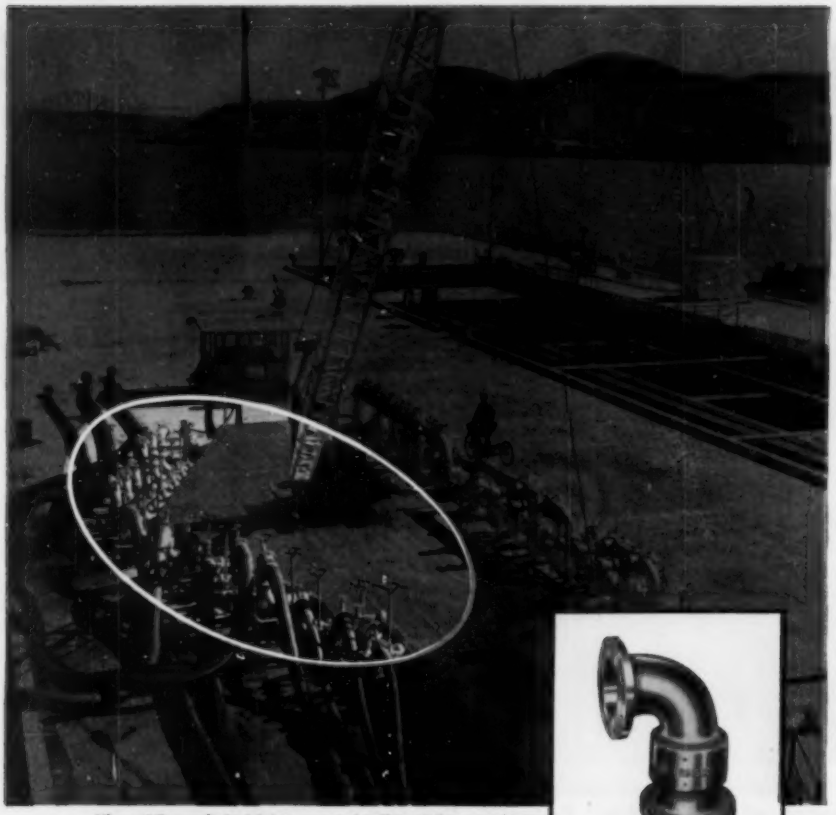
PHILADELPHIA 33, PENNA.

New England Agent: JONES & HUNT INC., Gloucester, Mass.
Cable Address: "NADRYMA"—W. U. Code



View of Emsco Swivel Joints on one loading station.

Emsco 8" type LP Swivel Joint Style 2 with flanged ends for loading dock service.

EMSCO SWIVEL JOINTS SELECTED FOR NEW LOADING WHARF

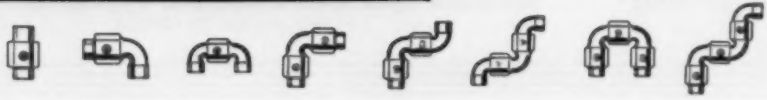
We are proud to have supplied the Swivel Joints installed on this loading wharf making it one of America's newest and most modern loading facilities. Here are installed a score of Emsco 6" and 8" type LP Swivel Joints. Free turning and easy maintenance were prime factors in the selection of Emsco for this job. In the cross section note how the thrust load is absorbed through the ball bearings — how easily bearings can be adjusted. Note also how readily the packing can be replaced simply by separating the joint as one would a union. No return of joint to the factory for service. Emsco assures you a new kind of dependability in Swivel Joints.

Emsco's complete line includes Swivel Joints for high or low pressure, high vacuum, corrosive or high temperature service; for gas, liquid or semi-solids. Check with us or our field representatives. Over 500 various combinations to choose from. Sizes ⅜" to 12". Pressures to 15,000 lbs. Temperatures to 750° F.

Simplicity of Emsco's patented design assures a new kind of performance and dependability in Swivel Joint construction.

EMSCO

EMSCO MANUFACTURING COMPANY
Box 2098, TERMINAL ANNEX
LOS ANGELES 54, CALIF.
Houston, Texas
Garland, Texas



FUTURE MEETINGS and Symposia of the Institute

MEETINGS **SYMPOSIA**

■ LAKE PLACID, N. Y.

Sept. 25-28, 1955. Lake Placid Club.

A meeting devoted to the problems of interest to top management.

NOTE—No general papers

TECHNICAL PROGRAM CHAIRMAN: L. J. Coulthurst, Mgr. Proc. Engr., Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.

Chemical Engineering Organizations of the Future

CHAIRMAN: J. F. Thornton, Pres., The Lummus Co., 385 Madison Ave., New York 17, N. Y.

Growth of the Oil & Chemical Industry by Integration

CHAIRMAN: F. M. Simpson, Vice-Pres., Petroleum Chemicals Inc., 54 Wall St., New York 5, New York

Packaged Power

CHAIRMAN: H. Arthur Martin, Exec. Vice-Pres., J. F. Pritchard Co., Kansas City, Mo.

Social Responsibilities

CHAIRMAN: James Donovan, Pres. Artisan Metal Products, Inc., 73 Pond St., Waltham 54, Mass.

Atom Profits

CHAIRMAN: W. Kenneth Davis, Reactor Dev. Div., U. S. Atomic Energy Comm., 1901 Constitution Ave. N.W., Wash., D. C.

Deadline Past

■ ANNUAL—DETROIT, MICH.

Nov. 27-30, 1955. Statler Hotel.

TECHNICAL PROGRAM CHAIRMAN: T. J. Carron, Supervisor, Chem. Eng. Section, Ethyl Corp., Res. Labs., 1600 West Eight Mile Road, Detroit 20, Mich.

Experiences in Nuclear Engineering Education

CHAIRMAN: R. P. Genereaux, Eng. Dept., Dupont Co., Wil., Del.

Biochemical Engineering

CHAIRMAN: H. O. Halvorsen, Dept. of Bacteriology, Univ. of Illinois, 362 Noyes Lab. of Chem., Urbana, Illinois.

Technical Societies Cooperation with Chemical Engineering Industries

CHAIRMAN: J. B. Phillips, Dept. Chem. Eng., Phys. Sciences Centre, McGill Univ., Montreal 2, Canada.

Mechanics of Bubbles and Drops

CHAIRMAN: R. C. Kintner, Dept. Chem. Eng., Ill. Inst. of Tech., 3300 Federal St., Chicago 16, Ill.

Standardization of Centrifugal Chemical Pumps

CHAIRMAN: C. J. B. Mitchell, Engineering Service Div., Engin. Dept., E. I. duPont deNemours Co., Inc., Wil., Del.

Evaporators

CHAIRMAN: W. L. Badger, 309 S. State St., Ann Arbor, Mich.

Liquid Metals in Chemical Industry

CHAIRMAN: C. F. Bonilla, Dept. of Chem. Eng., Columbia U., N. Y. 17, N. Y.

Deadline Past

■ LOS ANGELES, CALIF.

Feb. 26-29, 1956. Statler Hotel.

TECHNICAL PROGRAM CHAIRMAN: T. Weaver, Proc. Eng., The Fluor Corp., Ltd., Box 7030, East L. A. Station, Los Angeles 22, Calif.

MEETINGS **SYMPOSIA**

New Techniques for Utilization of Fast Reactions & Freezing of Equilibria

CHAIRMAN: W. H. Corcoran, Cal. Inst. of Tech., 1201 E. Cal. St., Pasadena, Cal.

Current Status of Completely Automatic Process Units

CHAIRMAN: F. C. Brunner, C. F. Braun & Co., 1000 S. Fremont Ave., Alhambra, Cal.

Supervision of Technical Personnel (Panel)

CHAIRMAN: R. D. Gray, Cal. Inst. of Tech., 1201 E. Cal. St., Pasadena

Techniques of Economic Justification for Process Industry Projects

CHAIRMAN: H. E. Wessel, Interna'l. Minerals & Chem. Corp., 20 N. Wacker Dr., Chicago, Ill.

Deadline—Oct. 26, 195

■ **NEW ORLEANS, LA.**

May 6-9, 1956

TECHNICAL PROGRAM CHAIRMAN: H. E. O'Connell, Assoc. Dir. Process Div., Sect., Ethyl Corp., Box 341, Baton Rouge, La.

■ **PITTSBURGH, PA.**

Sept. 9-12, 1956

TECHNICAL PROGRAM CHAIRMAN: Carl C. Monrad, Carnegie Institute of Technology, Pittsburgh, Pa.

UNSCHEDULED SYMPOSIA

Extraction of Hydrocarbons for Chemical Use from Pipeline Gases

CHAIRMAN: E. E. Frye, J. F. Pritchard & Co., 210 W. 10th, Kansas City 5, Mo.

Distillation Computation Methods

CHAIRMAN: Wayne C. Edmister, California Res. Corp., Richmond, Calif.

■ **GALVESTON, TEXAS**

October 14, 1955. Galvez Hotel

One-day Technical Meeting of the South Texas Section (10th Annual).

CHAIRMAN: W. L. Bolles, Monsanto Chemical Co., Texas City, Tex.

PROGRAM CHAIRMAN: Earl Manning, Shell Oil, Houston, Tex.

■ **CHARLOTTESVILLE, VA.**

Oct. 21, 1955 U. of Virginia

Half-day symposium on "Drying" sponsored by the Central Virginia Section of the A.I.Ch.E.

SYMPOSIUM CHAIRMAN: S. J. Friedman, DuPont, Waynesboro, Va.

Contact Chairman by August 1 to submit paper for symposium.

■ **CLEVELAND, OHIO**

Dec. 12-17, 1955. Cleveland Auditorium.

EJC Nuclear Eng. & Science Congress

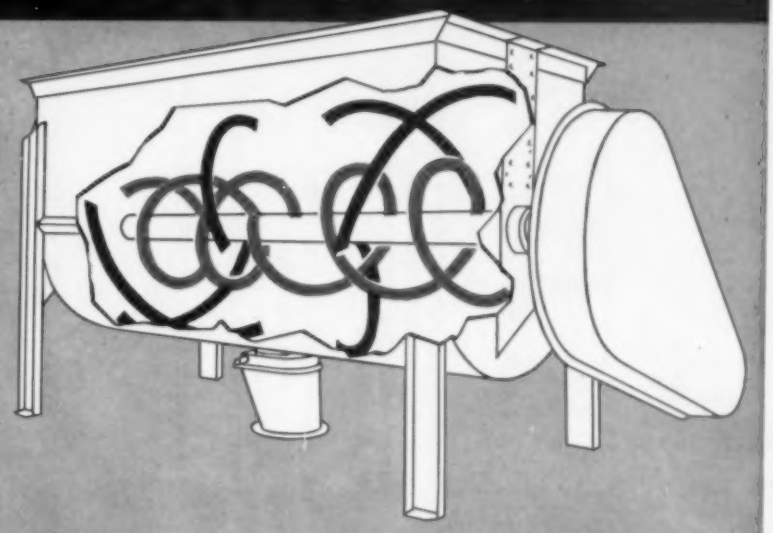
PROGRAM CHAIRMAN (A.I.Ch.E.): W. K. Woods, General Electric Co., Richland, Wash.

Liquid Metals in Nuclear Power

CHAIRMAN: C. F. Bonilla, Dept. of Chem. Eng., Columbia U., N. Y. 17, N. Y.

(*Continued on page 52*)

FOR CONTINUOUS OR BATCH OPERATIONS



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assures rapid, thorough mixing or blending of pulverized or granular, wet or dry materials.

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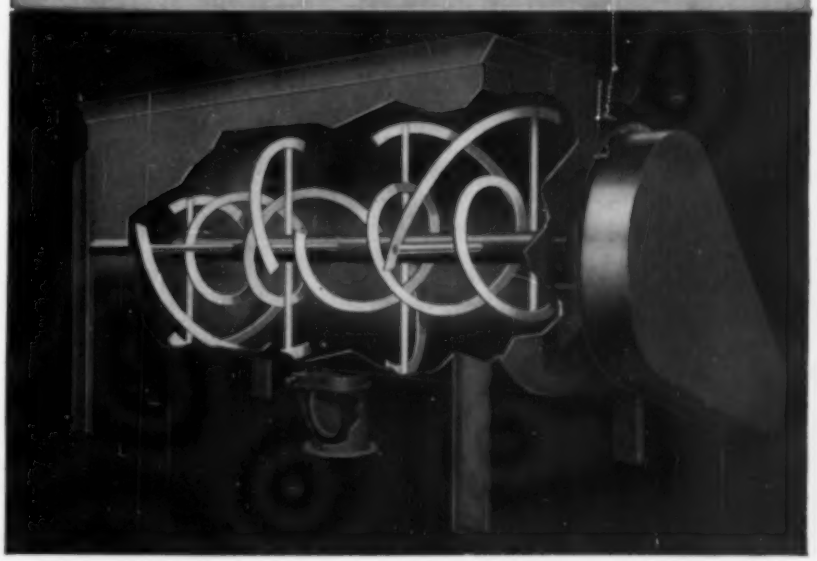

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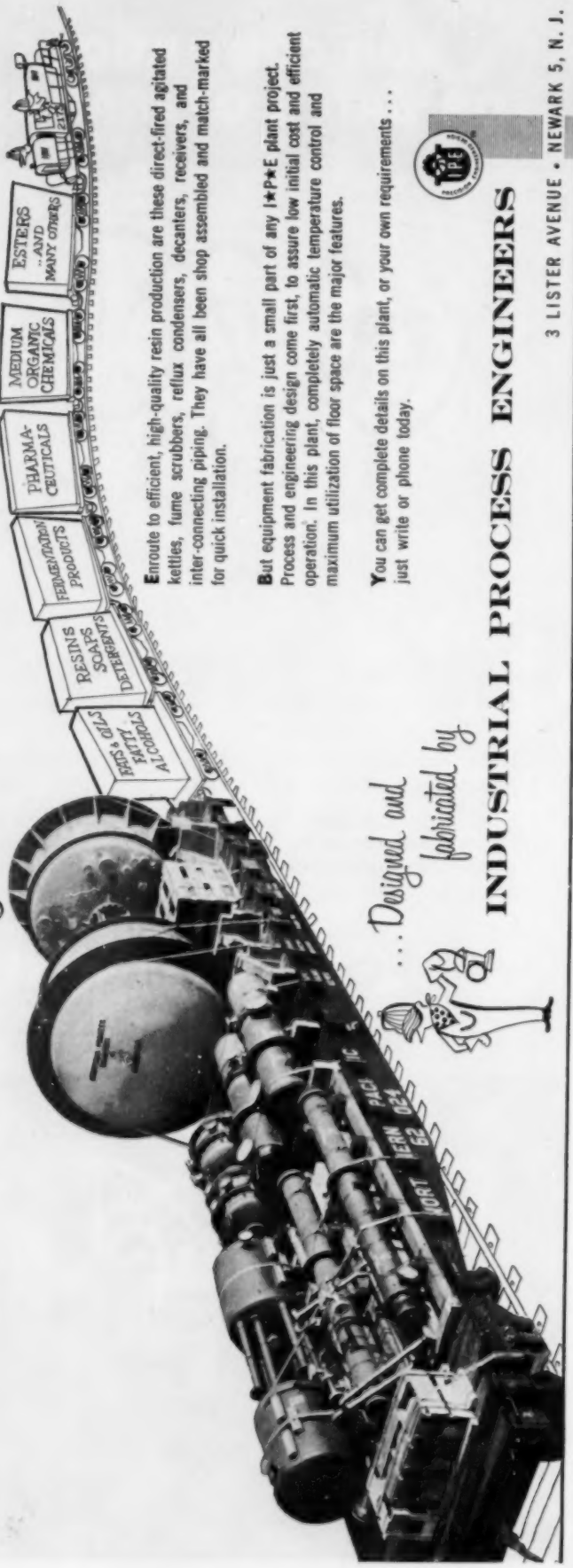

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FUTURE MEETINGS

(*Continued from page* 51)

AUTHOR INFORMATION

Submitting Papers

Members and nonmembers of the A.I.Ch.E. who wish to present papers at scheduled meetings of the Institute should follow the following procedure.

First, write to the Secretary of the A.I.Ch.E., Mr. F. J. Van Antwerpen, American Institute of Chemical Engineers, 25 West 45th Street, New York, requesting three copies of the form "Proposal to Present a Paper Before the American Institute of Chemical Engineers." Complete these forms and send one copy to the Technical Program Chairman of the meeting for which the paper is intended, one copy to the Assistant Chairman of the A.I.Ch.E., Program Committee, address at the bottom of this page, and one copy to the Editor of Chemical Engineering Progress, Mr. J. B. Mellecker, 25 West 45th Street, New York.

If you wish to present the paper at a particular symposium, request 4 copies of the proposal sending a copy to the Chairman of the symposium.

Before Writing the Paper

Before beginning to write your paper you should obtain from the meeting Chairman, or from the office of the Secretary of the A.I.Ch.E. at 25 West 45th Street, New York, a copy of the A.I.Ch.E. Guide which covers the essentials required for submission of papers to the A.I.Ch.E. or its magazines.

Copies of Manuscript

Five copies of each manuscript must be prepared. For meetings, one should be sent to the Chairman of the symposium, and one to the Technical Program Chairman of the meeting at which the symposium is scheduled. If no symposium is involved, the two copies should be sent to the Technical Program Chairman. The three other copies should be sent to J. B. Mellecker, Editor of C.E.P., 25 W. 45, N. Y. 36, N. Y. All manuscripts submitted to the A.I.Ch.E. Editor are automatically considered for C.E.P., the A.I.Ch.E. Journal, and the Symposium Series. Presentation at a meeting is no guarantee that manuscripts will be accepted.

Chairman, A.I.Ch.E. Program Committee, George Armistead, Jr., George Armistead & Co., 1200 18th St., N.W., Washington, D. C.

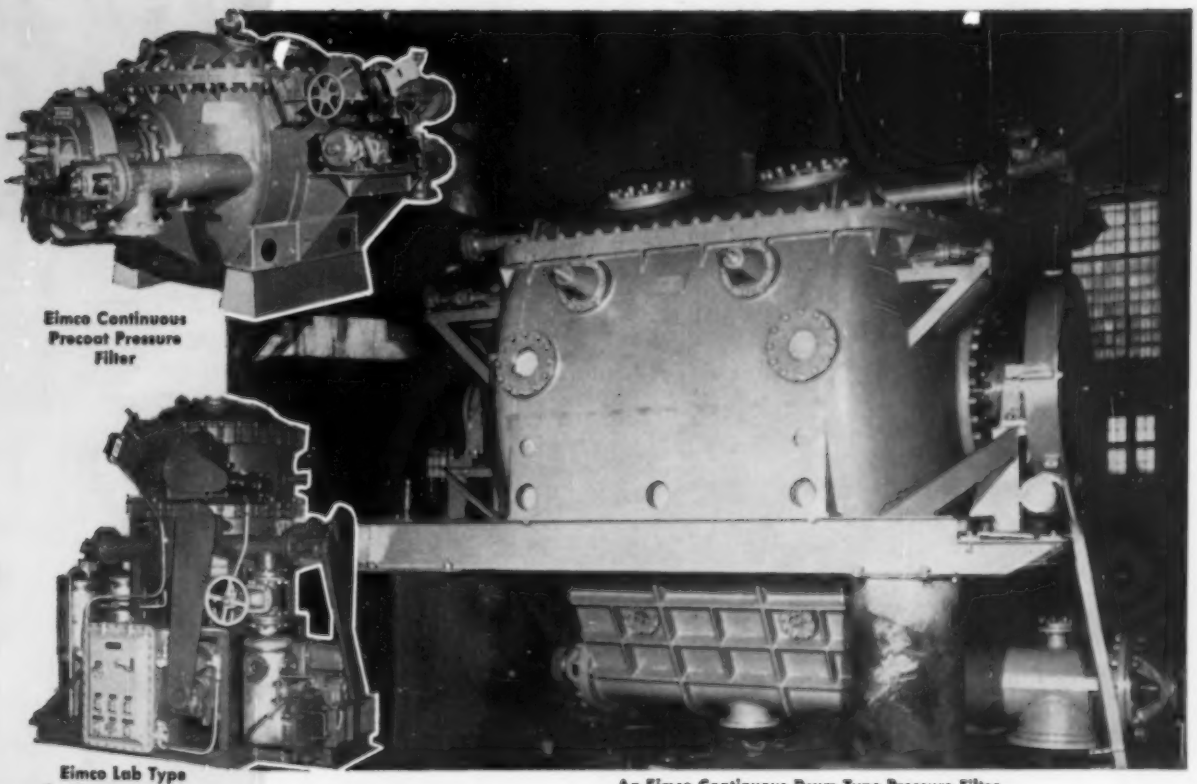
Assistant Chairman, L. J. Coulthurst, Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.

Interim plant for the production of a **new high density, boilable polyethylene plastic** will be in operation by the end of the summer at Monsanto's Texas City, Texas, plant. A small pilot plant at the company's Dayton, Ohio, Chemical Research Dept. has been in operation for several months. □

Water-borne sewage can be sterilized by gamma-radiation without activating or leaving residual radiation in the treated liquids. This is the conclusion of six months' research by sanitary engineers at the Corps of Engineers' Research and Development Laboratories, Fort Belvoir, Va. □

Industry plans $300,000,000 investment in atomic energy research in the next four years, according to a report just released by the Atomic Industrial Forum, Inc.

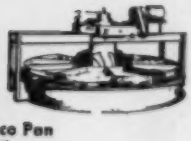
By 1965, atomic energy developments, both Government and private, will call for a total of 30,000 to 40,000 scientists and engineers—about double the number in both categories today. □



Eimco Continuous Precoat Pressure Filter

Eimco Lab Type Continuous Pressure Precoat Drum

An Eimco Continuous Drum Type Pressure Filter



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offers a means of solving difficult process problems which have heretofore been unanswerable.

These filters are offered only after the problem has been studied by Eimco's Research and Development Division and each filter station is then designed and constructed to handle each user's problem on an assured result basis.

Pilot plant operations are conducted on proportional sized filtration equipment of all types in Eimco's Research and Development Center or in the customer's own plant.

Successful production size installations based on findings made by Eimco's Research and Development Division prove the value of starting new flow sheets through this thorough and exhaustive method of testing to obtain all the facts.

Let us tell you more about Research in liquids-solids separation through filtration.

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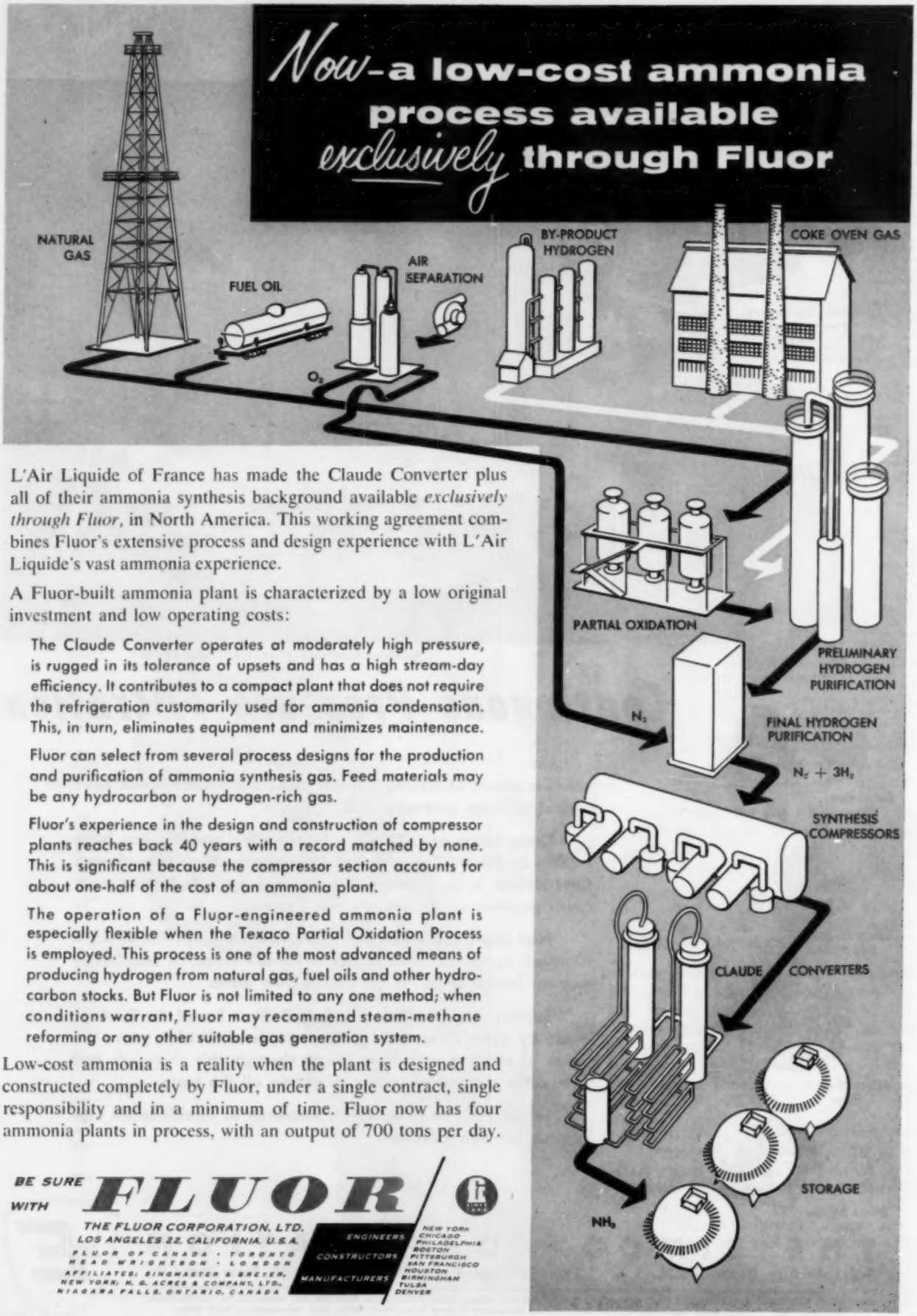
B-184

Now-a low-cost ammonia process available *exclusively* through Fluor



L'Air Liquide of France has made the Claude Converter plus all of their ammonia synthesis background available *exclusively through Fluor*, in North America. This working agreement combines Fluor's extensive process and design experience with L'Air Liquide's vast ammonia experience.

A Fluor-built ammonia plant is characterized by a low original investment and low operating costs:

The Claude Converter operates at moderately high pressure, is rugged in its tolerance of upsets and has a high stream-day efficiency. It contributes to a compact plant that does not require the refrigeration customarily used for ammonia condensation. This, in turn, eliminates equipment and minimizes maintenance.

Fluor can select from several process designs for the production and purification of ammonia synthesis gas. Feed materials may be any hydrocarbon or hydrogen-rich gas.

Fluor's experience in the design and construction of compressor plants reaches back 40 years with a record matched by none. This is significant because the compressor section accounts for about one-half of the cost of an ammonia plant.

The operation of a Fluor-engineered ammonia plant is especially flexible when the Texaco Partial Oxidation Process is employed. This process is one of the most advanced means of producing hydrogen from natural gas, fuel oils and other hydrocarbon stocks. But Fluor is not limited to any one method; when conditions warrant, Fluor may recommend steam-methane reforming or any other suitable gas generation system.

Low-cost ammonia is a reality when the plant is designed and constructed completely by Fluor, under a single contract, single responsibility and in a minimum of time. Fluor now has four ammonia plants in process, with an output of 700 tons per day.

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developments of the month–

134. Can you use a glassed steel conical dryer-blender?

Pfaudler Co., Rochester, N. Y., has scale models of their new standard units now available for product testing either at their laboratory or (through loan) for use in your own plant.

Experimental results with the scale models are said to give reliable indications for practical process use in production sized equipment.

According to Pfaudler, the new dryer can be used for all acids except hydrofluoric, alkalies up to pH 12. Glassed steel insides resist adherence, improve heat transfer, reduce clean-up loss and labor, eliminate metallic contamination.

In operation the dryer revolves slowly, hot water or steam circulates through the jacket, vacuum exhaust removes vapors. Standard unit jackets are rated to take up to 40 lb./sq.in. pressures with full vacuum inside.

Standard units are available in 2-, 4-, 6- and 8-foot diameters, volumes ranging up to 150 cu.ft. working capacity, internal pressures from full vacuum to 20 lb./sq.in., each unit tested to meet ASME code specifications.

Tests are free of charge, available from Project Engineering Dept., The Pfaudler Co., 1000 West Ave., Rochester 3, N. Y. For further information, encircle number on Data post card.

(Continued on page 56)

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6L Process Pumps. Pacific pumps said to insure more service for you with less servicing by you. Pacific Pump Inc.

7A Process Plants. Plants for the production of ammonium nitrate, nitric acid, & complex fertilizer, as well as others designed & built by Chemical and Industrial Corp.

8A Valves. Packless diaphragm valves the Crane Kel-F require little maintenance & are available in wide selection of body materials & trims. Crane Co.

9A Grinding Equipment. Mikro-Aircon is an automatic, dust-free system easily cleaned between runs. Pulverizing Machinery Div., Metals Disintegrating Co., Inc.

10L Oil Reclaimer. Continuous recirculation of vacuum pump oil either on a full-flow or by-pass basis using Hilco oil reclaimer from Hilliard Corp.

11A Motor Protection. Use of the ingenious Ventrifoil at each end of a motor directs air & deflects water. U. S. Electrical Motors Inc.

12A Pipe Insulation. Called Unibestos this pipe insulation holds temperatures at desired level. Available in 3 ft. lengths in pipe sizes ½ through 24 in. Union Asbestos & Rubber Co.

13A Filters. Poro-stone filters provide efficient filtration for critical process requirement in electrolytic preparation of hydrogen peroxide. Available from R. P. Adams Co., Inc.

14A Celite. Filtration with Celite filter cake assures perfect clarity. Nine standard grades of microscopically controlled particle size. Johns-Manville.

15A GLC Anodes. Dependable, these anodes are used by many major producers of chlor-alkali. Great Lakes Carbon Corp.

16A Chempump. Combines pump & motor in single hermetic unit. From ⅛ to 7½ h.p. capacity. May be run 16 hrs. a day, 5 days a week. Chempump Corp.

17A Tubing. Fabricated of stainless steel, tubing gives optimum in strength, corrosion & oxidation resistance. There is a grade to suit your every need. Babcock & Wilcox Co.

18L Shaft Seals. Made of Dupont Teflon & said to give unsurpassed performance with longer life Chemiseal mechanical seals. United States Gasket Co.

19A Lithium. On stream a new lithium plant to produce lithium carbonate & lithium hydroxide for industry at large. Lithium Corporation of America, Inc.

20L Line Blind Valves. Foolproof sealing action provided by Hamer blinds. Fast, one minute, one man operation literally pay their cost in saving of downtime. Hamer Valves Inc.

21A Petrochemical Plants. Designed, engineered & under construction in England a new ethylene plant utilizing the unique steam-cracking process of M. W. Kellogg Co.

22L Standard Trays. Types available for high vapor loads, high liquid loads, or average operations. Variables are cap size, cap spacing, skirt clearance. Badger Mfg. Co.

23A Centrifugal Pumps. Efficient centrifugation of filterable slurries obtained using either of two types of centrifugals from Baker Perkins, Inc.

24L Girdler Catalyst. Use of this material has cut consumption of expensive hydrogenation catalyst in half. Technical personnel available for consultation. Girdler Co.

25A Air Preheater. Reduce slag by use of the Ljungstrom air preheater. Permits air to mix thoroughly with fuel. Air Preheater Corp.

26A Conveyor. The pushbutton S-A Redler system moves chemicals in dust-free, moisture-protected flow. Answers moving problems from coal to cornstarch. Stephens-Adamson Mfg. Co.

27A Dowtherm. Responds to a fraction-of-a-degree control at temperatures to 750° F. Provides low-pressure, high-temperature heat. Dow Chemical Co.

28A Stainless Steels. To secure the ultimate in quality an alloy products shop for the exclusive fabrication of stainless & alloy steel products. Sun Shipbuilding & Dry Dock Co.

29A Heat Exchangers. For higher outputs at lower temperatures Trane heat exchangers. At —300° F. these units of brazed aluminum perform efficiently. Trane Co.

30A Anhydrous Ammonia. A new Girdler built plant will soon supply New England agriculture & industry with this material locally. First to use low grade oil as raw material. Girdler Co.

33A Crystallization. If yours is a crystallization problem experienced engineers will gladly cooperate with you. Consult with specialists in the field. Struthers Wells Corp.

34A Process Equipment. Fabrication of complex pressure vessels is a specialized business. Experience with all phases of the industry produces quality units. Downington Iron Works, Inc.

39A Karbate Equipment. Use of Karbate an impervious graphite in the construction of process equipment eliminates corrosion, plus effects of thermal shock. National Carbon Co., Div. Union Carbide and Carbon Corp.

40L Ball & Pebble Mills. The answer to scores of important queries on the subject are given in the "Hand Book of Ball and Pebble Mill Operation" from Paul O. Abbe, Inc.

41A Chemical Plants. If you are contemplating building a new chemical plant specialists will assist in engineering & other phases. Consult Foster Wheeler Corp.

42L Fluid Control. Valves fitted with an O-ring stem seal become star performers in field of fluid control. Provide a leak-tight seal. Hoke Inc.

43A Oxidation Process. Now a third plant for production of ethylene oxide is using SD's process of direct oxidation of ethylene. It is available to you too. Scientific Design Co., Inc.

45A Stainless Steel Parts. If you want dependable, economically produced stainless steel plates, bars, rounds other shapes with delivery guaranteed write to G. O. Carlson, Inc.

46L Panarez Resins. Special rubber compounds using Panarez resins for wire covering applications result in better products. Pan American Chemicals Corp.

47A Autoclave Valve. Do you want fingertip operation at 30,000 lb./sq.in.? Investigate the features of this product of Autoclave Engineers, Inc.

49A Conveyor Dryers. New construction, improved housing panels, super-power fans are but a few of the features of conveyor dryers from National Drying Machinery Co.

50L Swivel Joints. Units available for high or low pressure, high vacuum, corrosive or high temperature, & for gas, liquid or semi-solids. Emsco Mfg. Co.

DEVELOPMENTS OF THE MONTH *(Cont.)*

135. Need tool kit for PVC or Polyethylene construction? by welding thermoplastics? American Agile Corp., Bedford, Ohio, now has complete kits to fill the bill.

In each $150 kit are two books, "Welding of Plastics," and "Plastics Welding Manual," written by authorities and including all the know-how needed by even the most inexperienced person. In addition, the kit contains a 110-volt welding gun with nozzle, 15 feet of nitrogen hose, electrical connections, a nitrogen flowmeter with tubing, a contour marker, a porosity spark tester, marking crayons, and a cutting-trimming knife. Circle number 135 on Data card.

Detailed information can be had by encircling number on Data postcard.

(Continued on page 58)

51R Mixers. Rapid, thorough mixing or blending of pulverized or granular, wet or dry materials accomplished in these Readco units. Read Standard Corp.

52L Process Plants. Complete information on plants for fats & oils, organic chemicals, esters, & many others available from Industrial Process Engineers.

53A Filtration. Continuous pressure filtration often solves difficult process problems. For more research information in liquids-solids separation write to Eimco Corp.

54A Ammonia Process. Using a Claude converter in a Fluor engineered plant results in a low-cost ammonia process. Floor Corp., Ltd.

59A Spray Dryers. An illustrated booklet will provide you with proof of the efficiency of Bowen units. Bowen Engineering, Inc.

61A Filters. Design of Staynew filters permits use of any medium in sheet form that can be crimped. If you have a problem write to Dollinger Corp.

63A Process Equipment. Haveg 1810 polyvinyl chloride used in the fabrication of process equipment results in low cost, corrosion resistant units. Haveg Corp.

64L Filters. Sparkler horizontal plate filters give versatile adaptability. Constant filter quality is maintained. Sparkler Mfg. Co.

65A Separator Concentrator. Unit designed to handle liquid flows to 18,000 gal./hr. with parallel drive to handle power loads to 50 h.p. Sharples Corp.

66L Heat Exchanger. Impervite an impervious graphite used to make this unit withstand 200 lb./sq.in. Other exclusives listed in ad. Falls Industries, Inc.

67A Autoclave. A 600 gal. unit of ductile cast iron for use in a methylation process. Improved mechanical properties obtained because of microstructure of the iron. International Nickel Co., Inc.

68L Heat Exchangers. To obviate interleakage between shell & tube circuits of a heat exchanger double tube sheet is the answer. Whitlock Mfg. Co.

69R Mechanipak Seal. For shafts from ⅜ to 3 in. diam. the BB-21A Mechanipak seal reduces shaft wear, cuts downtime, reduces maintenance. Garlock Packing Co.

70L Liquid Level Control. Even if yours is a specialized problem Magnetrol will meet your need. Operation is so simple no basic design changes are needed. Magnetrol, Inc.

71A Insulation. You can get the answer to your insulation problem by simply calling your nearest J-M insulation contractor. Johns-Manville.

Numbers without letters indicate data available as described in Data Service "Briefs." Numbers with letters refer to further data concerning products advertised in this issue. Letters indicate position of advertisement on page (if more than one on a page)—L, left; R, right; T, top; B, bottom; A indicates full page; IFC, IBC, and OBC are cover advertisements.

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61A	63A	64L	65A	66L	67A	68L	69R	70L
71A	72L	73R	74L	75A	76TL	76BL	77R	78L
79R	81R	82L	83R	84L	86L	86R	87TR	87BL
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46L	47A	49A	50L	51R	52L	53A	54A	59A
61A	63A	64L	65A	66L	67A	68L	69R	70L
71A	72L	73R	74L	75A	76TL	76BL	77R	78L
79R	81R	82L	83R	84L	86L	86R	87TR	87BL
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73R Propeller Pumps. Made of metals & alloys best suited to resist corrosive & abrasive action pumps are widely used in the chemical & process industries. Lawrence Pumps, Inc.

74L Flasks. Dewar flasks of aluminum base, silvered & unsilvered, of Pyrex & lime glass available from Ace Glass Inc.

75A Plant Sites. If water is your problem ask for free Industrial Site Water Survey brochures. St. Louis-San Francisco Railway.

76TL Fin & Pipe Coils. Made of stainless steel these fin & pipe coils handle all types of corrosive air mixtures or liquids to be heated or cooled. Rempe Co.

76BL Spray Nozzles. Thousands of standard industrial spray nozzle types & sizes to choose from. Ask for the new catalog from Spraying Systems Co.

77R Feeders. Standard Hardinge feeders regardless of capacity are suspended from the feed bin eliminating costly support structure & providing accessibility to equipment following feeder. Hardinge Co., Inc.

78L Rotary Filters. For continuous separation of coarse crystalline or fibrous pulps this simple, fast vacuum filter provides six advantages. Filtration Engineers, Inc.

79R Proportioning Pump. Type K hydraulic metering & proportioning pump eliminates most oft he usual problems. Available in one & two feed units. Hills-McCanna Co.

81R Heat Exchangers. Named Paracoil this unit may be used to reduce water content in tallow plus all its other applications. Davis Engineering Corp.

82L Adsorbents & Desiccants. Problems of selective adsorption, dehydration, decolorization, catalysis can be solved by use of one of twenty products. Floridin Co.

83R Stainless Steel Fittings. Three good reasons for buying these stainless steel fittings are availability, quality, & a complete line. Cooper Alloy Corp.

84L Tunnel Truck Dryers. Use of these dryers insures flexible operation, unitized construction, quick erection, easy expansion. Proctor & Schwartz, Inc.

86L Silicone Defoamer. Space wasted by foam may be used to increase your output up to 100% without installation of new equipment. Dow Corning Corp.

86R Accurate Sizing. Several types of equipment that accurately sizes or separates may be the answer to sizing your granular materials. Hart-Carter Co.

87TR PVC Parts. Injection-molded PVC fittings & flanges for strong corrosion resistant piping. Both high and normal impact strengths. Tube Turn Plastics, Inc.

87BL Vacuum Equipment. Steam jet ejectors, condensers, vacuum equipment available from Jet-Vac Corp.

87BR Research. Inquiries on your research problems are invited without cost or obligation to you. Foster D. Snell, Inc.

88TL Process Equipment. Individual items of equipment up to pilot plants & complete plants designed and manufactured by Artisan Metal Products, Inc.

88BL Filtration. Just published, a new catalog which contains everything you must know about filtration & its application to your process. D. R. Sperry & Co.

89R Junior Tube Cleaners. Especially for cleaning small tubes, the Rotojet. Equipped with expanding heads & brushes. Elliott Co.

90TL Kerodex. Spread it like cream & it acts like a glove in protection against harmful industrial skin irritants. Types for wet & dry work. Ayerst Laboratories.

90BL Sprocket Rim. Every valve becomes easily accessible using this adjustable sprocket rim with chain guide. Babbitt Steam Specialty Co.

91TL Claw Propellers. Craddock stainless steel claw propellers will speed production & improve mixing results. Designed, engineered & patented by Craddock Equipment Co., Inc.

91BL Arched Wafers. A new process & a new service. Arched wafers said to have many advantages over flakes & other shapes. Flakice Corp.

91R Dust-Tite Valves. Many times each day a Gemco valve has opened & closed without giving trouble. Complete information available. General Machine Co. of New Jersey.

96TL Coolers. Fabricated from stainless steel coolers are unusually well suited for Freon. If you have a cooler problem contact Richard M. Armstrong Co.

96BL Laminates. Glass reinforced polyester, epoxy, & phenolic laminates for corrosion resistance & electrical insulation. Carl N. Beetle Plastic Corp.

97TR Konisampler. For continuous, accurate dust sampling, or for permanent records the portable Konisampler. Joseph B. Ficklen III.

97BR Chill-Vactor. Units flash cool water, aqueous solutions & certain other liquids to temperatures of 32° F. Croll-Reynolds Co., Inc.

IBC Water Treatment. A new bulletin available provides economical solutions to all industrial water problems. Write for it. Milton Roy Co.

OBC Lightnin Mixers. Want to know how you can depend on optimum fluid mixing? Call your Lightnin mixer representative. Mixing Equipment Co., Inc.

298A Horizontal Filter. Only one operator required to handle several of these filters. Horizontal & vertical types available. Niagara Filters Div. American Machine and Metals, Inc.

materials-

1. Ethyl Acetate. Carbide and Carbon Technical booklet on uses, physical & physiological properties, specifications.

2. Phthalate Plasticizers. Added to line of Pittsburgh Coke & Chemical Co. Pittsburgh PX-120. Provide unique combination of properties.

3. Chemicals Handling & Storage. Second in series of Sauerman Bros., Inc. brochures. Basic chemicals & corrosion discussed, units described.

4. Paraformaldehyde. Celanese paraformaldehyde described as economic source, Bulletin N-30.

5. Dibutyl Fumarate. Monsanto bulletin for manufacturers & formulators of plastics & other products.

6. Sodium Lauryl Sulfate. For use in dentifrices, pharmaceuticals, cosmetics, Sipon WD crystals of high purity grade available from American Alcolac Corp.

7. Polyglycol Ether. Ansul Chemical Co. Ether 181 described as a solvent for removal of neoprene compounds quickly & efficiently.

8. Copolymer Resin. Firestone Plastics Exon 450 vinyl chloride copolymer resin of intermediate molecular weight. Soluble in ketones & will tolerate aromatic hydrocarbons. Bulletin lists physical properties, etc.

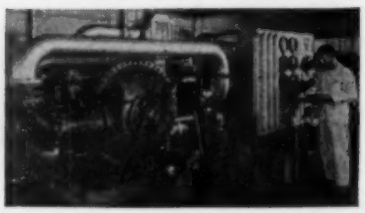
9. Oleic Acids. "Emersol Oleic Acids," Emery Industries, Inc. brochure emphasizes end-product performance.

10. Polyethylene Waxes. Epolne "E" & "N" Eastman Chemical Products, Inc. booklet covers technical data, charts & tables, other pertinent data.

11. Silicone Defoamers. Antifoam AF emulsion from Dow Corning Corp. data in new brochure. Concentrations, dispersing media & application methods.

(Continued on page 60)

DEVELOPMENTS OF THE MONTH (Cont.)

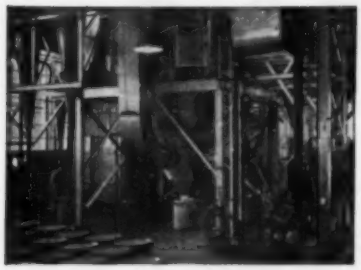


136. New line of Centrifugal Compressors. Ranging in size and capacity from 500 to 65,000 CFM, this new product line now augments The Cooper-Bessemer Corporation, Mount Vernon, Ohio, standard line of reciprocating compressors.

Designed to have their major application in refineries, ammonia and petrochemical plants, gas transmission lines, and generally throughout the process industries, typical units are already in service.

Further information is yours by encircling number 136 on Data post card.

(Continued on page 60)



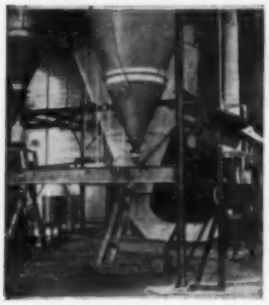
21 Recent Bowen Spray Dryer Installations that help prove the fact that

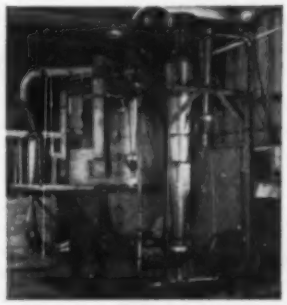
BOWEN SPRAY DRYERS

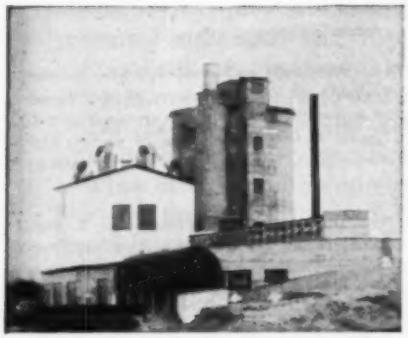
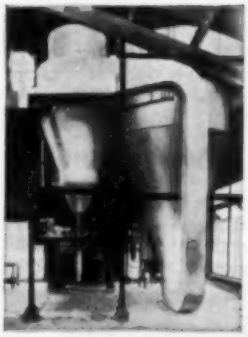
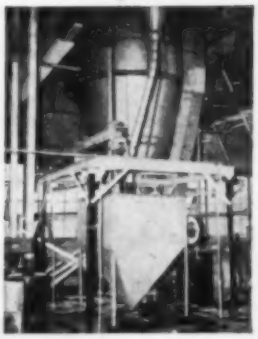
***Always* Offer You More!**

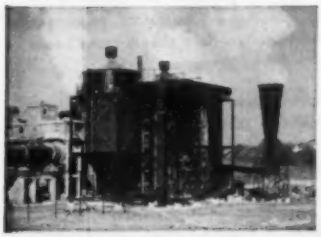
Write for illustrated booklet—
The Bowen Spray Dryer Laboratory

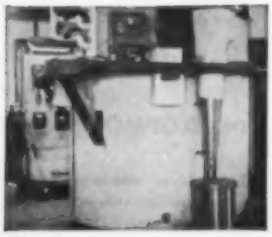
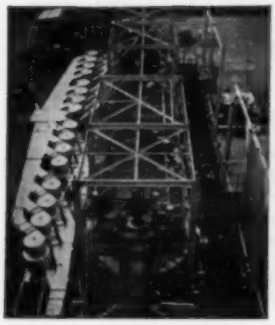
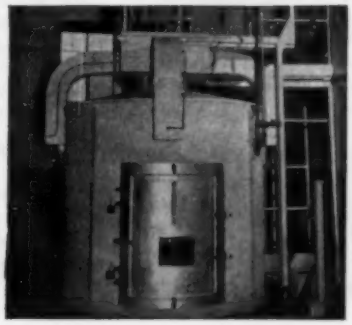
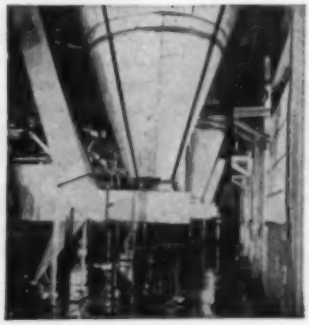
BOWEN ENGINEERING, INC.
NORTH BRANCH 13, N. J.







materials-(Cont.)

12. Gilsonite Coatings. Data sheet on Chlorowax 40 & 70; Diamond Alkali Co. Flame retardant & has good drying characteristics.

14. Emulsifiers. Many kinds of emulsifiers listed in Armour and Co. pamphlet. Properties of 24 classifications.

15. Plastisol Compounds. Series 4,000 & 5,300 plastisol compounds, United Chromium, Inc. unique vinyl materials with broad uses. Advantages, application, methods, etc.

16. Flame Retardant Plasticizer Celanese Celluflex CEF has high degree of flame retardance. Flexibilizing agent for polyesters, vinyls & cellulosics.

17. Butyl Carbitol. Data sheet on butyl Carbitol solvent for nitrocellulose & many resins, including other uses, from Carbide and Carbon.

18. Itaconic Acid. 20-page, index-type technical Bulletin from Pfizer outlines uses & properties of versatile organic compound available in commercial tonnages by fermentation.

19. Acrylic Emulsions. Rhoplex X-52 & B-85 by Rohm & Haas. Of superior hardness for coatings, adhesives, & impregnations for paper, rubber, & textiles.

21. Pipeline Corrosion Inhibitor. Universal Oil Products Co. brochure describes double action qualities.

22. Propylene Glycol. Data on physical, chemical & physiological properties, plus applications, from Carbide and Carbon Chemicals Co.

23. Polyesters for Polyurethanes. Two experimental polyesters for making polyurethane foams being offered by Reichhold Chemicals, Inc.

24. Amines. Sharples Chemicals 52-page book "Sharples Amines." Applications, chemical reactions, toxicology & physical properties covered.

25. Ethylene Polymer. Marlex 50 by Phillips Chemical is called revolutionary thermoplastic with high toughness, rigidity, & strength.

26. Polyethylene Resins. Booklet on U.S.I.'s Petrothene polyethylene resins includes handling information, chemical & physical data.

27. Machining Titanium. Information on turning, milling, drilling, reaming, sawing in leaflet from Mallory-Sharon Titanium Corp.

28. Organolithium Compounds. How to use these compounds in organic syntheses in supplementa No. 3 of the annotated bibliography from Lithium Corp. of Amer., Inc.

29. Low Pressure Polyethylene. Super Dylan polyethylene by Koppers Co., Inc. is described in bulletin. Applications, plus unusual physical properties covered.

30. Vinyl Resin Plasticizers. Four new plasticizers from B. F. Goodrich Chemical Co. Said to impart improved properties.

31. Silicone Antifoam Agent. Newly developed General Electric product said to have high efficiency, eliminates costly handling.

bulletins-

35. Flexible Metal Hose. Catalog of all types Flexon hose by Flexonics Corp. Full range of corrugated metal, convoluted, & stainless steel construction. Fast four-step selection plan. Complete coupling data.

36. Data Handling Systems. Multiple pressure readout systems for rapid data handling in process & pilot plants, experimental set ups, etc. illustrated in Fischer & Porter Co. catalog. Operation, applications, & performance characteristics listed.

37. Control Equipment. Technical literature from Wheelco Instruments discusses conventional millivoltmeter construction & its application to a control instrument, function of oscillator circuit in a pyrometer controller, plus other control forms.

38. Processing Equipment. ...e entire line of Alsop stainless steel process equipment including filters, agitators, & transfer pumps covered in new catalog. Custom designed units available.

39. Jet Pumps. Design, construction, installation, & operation of the A-S-H hydroejector covered in data sheet from Allen-Sherman-Hoff Co. Unit is designed to pump mixture of solids & water through transporting pipeline.

40. Sizers & Feeders. Pulva-Sizers and Com-Bin feeders, plus auxiliary equipment for grinding, feeding or materials handling in catalog from Pulva Corp. Design facilities & testing laboratory described as available for assistance in solution of specific problems.

41. Entrainment Separators. Metex mist eliminators for control of liquid entrainment in process equipment covered in folder from Metal Textile Corp. Data on new Hi-Thruput herringboned units.

42. Neoprene Liquid Lining. Gaco N-200-1 said to provide positive protection from corrosion & abrasion under severe immersion service. For tanks, pipes, valves, pumps, process equipment. Gates Engineering Co.

43. Temperature Control System. Bulletin available on general subject of application of automatic control to process applications. Typical section on selection of sensing elements & their correct use. Barber-Colman Co.

44. Thermoregulators. Magna-Set & Mercuthal Magna-Set items by Precision Thermometer and Instrument Co. said to have new high accuracy & sensitivity. Details in illustrated leaflet.

45. Control Instruments. Complete information on Speedomax indicators, recorders, & controllers in five data sheets from Leeds & Northrup Co. Discuss applications.

46. Spectrophotometer. Warren Electronics, Inc. offer a 20-page illustrated booklet on Spectracord. Describes instrument in detail, includes theory of operation, performance, versatility, & applications.

47. Simplex & Duplex Pumps. Philadelphia Pump and Machinery Co. illustrated catalog covers standard pumps with pressure ranges to 1,500 lb./sq.in.; low pressure models to 800 lb./sq.in. Capacities a few cc./hr. to 3,300 gal./hr. Also control mechanisms for varying capacity.

48. Controlled Volume Pumps. From Milton Roy Co. bulletin No. 455 on controlled volume pumps in paper making. For use in metering chemicals in stock preparation, bleaching, coating, slime & foam control, & water treating.

(Continued on page 62)

DEVELOPMENTS OF THE MONTH (Cont.)

137. New continuous contact column in which solids settle down through an upward flow of liquid, designed to utilize rotating shear plates on a vertical shaft, engineered, produced and marketed by Allis-Chalmers Manufacturing Company, Milwaukee.

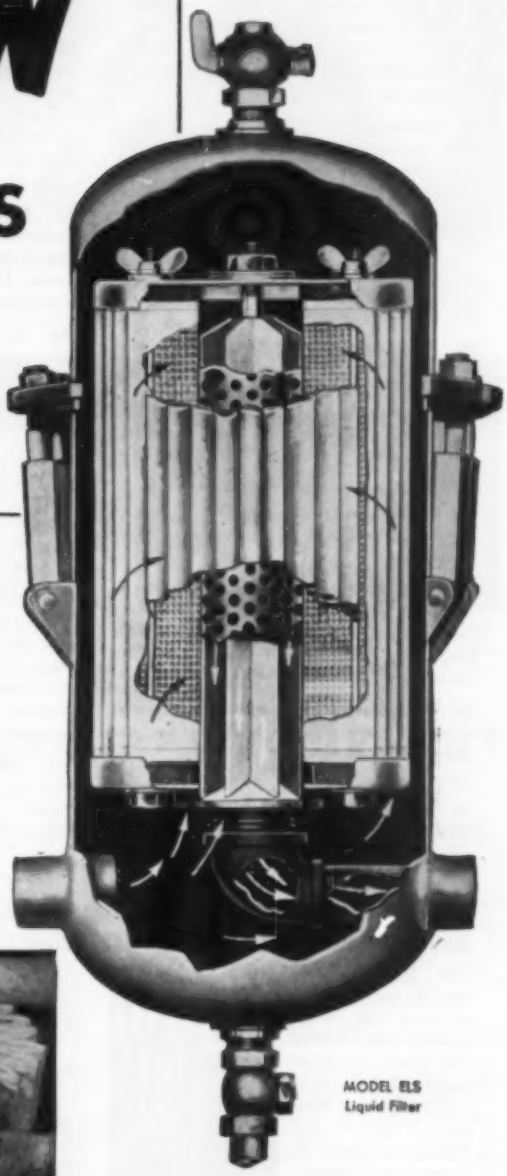
The column, developed by Allis-Chalmers for such operations as water, acid, and alkali ore leaching; dissolving; decolorization; ion exchange; molecular sieving; catalyzed reaction; absorption; and oil extraction, is fabricated of steel or corrosion-resistant metals, can be lined with rubber or other materials as required. Available in diameters from 12 to 84 inches, processing capacities up to 1,000 pounds per day in terms of solid flow.

The column has also found use as a continuous sludge settling device to aid in filtration.

A booklet on the column and its applications is available by encircling number 137 on Data card.

(Continued on page 62)

LET STAYNEW LIQUID FILTERS Solve Your Filtration Problems!



MODEL ELS
Liquid Filter

Bring your liquid filtration problems to Dollinger engineers. Their specialized experience is available in recommending the most efficient and economical equipment for filtering liquids in a wide range of viscosities, temperatures, acidities, alkalinities, pressures and capacities.

Staynew exclusive design, permits use of *any medium in sheet form that can be crimped.* Metal, plastic, fabric, ceramic and metallic mesh media can be used for super-fine filtration.

Write us today outlining your specific liquid filtration problem. From our 30 years experience in liquid filtration, we have built up a vast file of helpful information. Any part of this information is yours for the asking—no obligation.

Staynew Radial Fin Construction provides the largest possible filtering area for available space. Slip-On Insert—exclusive in Staynew Filters—permits simple, inexpensive cleaning or replacement of media.

Representatives in Principal Cities

DOLLINGER MFG. PROTECTOMOTOR PAT. STAYNEW FILTERS

DOLLINGER CORPORATION

79 Centre Pk., Rochester 3, N. Y.

ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

bulletins-(Cont.)

49. Spray Drying. Blaw-Knox Co., Inc. catalog now available. Flexibility, design features & capacities of five standard sizes explained. Vertical & horizontal dimensional requirements diagrammed to aid in planning space requirements.

50. Demineralizing. Selection guide compares methods of water treatment, compares demineralizers & evaporators, from Cochrane Corp. Also indicates when decarbonators or vacuum deaerators are required.

53. Packingless Diaphragm Valves. Crane Co. expanded line subject of illustrated brochure. Covers valve patterns, body & trim materials, linings, & operation.

54. Rotameters. Comprehensive loose-leaf catalog from Brooks Rotameter Co. describes flowmeters for liquids & gases, plus indicating, recording, controlling, & integrating accessories. Design features, capacity charts, other data.

56. Feeders. Bulletin from Fuller Co. on roll & vane-type feeders & rotary valves. Designed to handle variety of dry granular materials.

57. Pressure Pilot. Illustrated folder on U. S. Gauge pressure pilot—said to represent major advance. Compact, completely self-contained, incorporating features not usually available.

58. Temperature Transmitter. Illustrated bulletin from Moore Products Co. on Standard pneumatic (3 to 15 lb./sq.in.) transmission.

59. Centrifugal Pumps. New bulletin on Worthington Corp. Worthite centrifugal pumps for acids, alkalies, & slurries. Outline drawings of various types, rating charts, dimensions, parts lists, cutaway views.

61. Gradation Heating. Selas Corporation bulletin entitled "Gradiation Heating for Petroleum and Chemical Processing." Covers radiant gas heater design as well as processing & construction features.

63. Controlled Volume Pumps. For use in water treating these Milton Roy Co. controlled volume pumps are described in bulletin No. 953. Typical processes described include coagulation systems, lime soda softening, demineralization, & various types of boiler water treatment systems.

64. Porous Metal Filters. Standard size water filters for use with filter-aid to handle 8 to 939 gal./min. are described in leaflet from Micro Metallic Corp. Stainless steel filter elements.

65. Rotary Pressure Pumps. Precision built stainless steel units for transferring & metering by Marco Co., Inc. are illustrated & described in bulletin. Handles both light, volatile fluids or heavy, viscous materials.

66. Electroless Plating. Booklet from International Nickel Co., Inc. presents a summary of detailed information on commercial uses of electroless nickel plating. Fourteen specific installations & type of work handled by each are described.

67. Water Clarification. Graver Water Conditioning Co. Reactivator®, a cold process softener & clarifier said to successfully respond to problem of load variation. Two mechanical—two non-mechanical features essential to provide satisfactory clarification process.

68. Vibrating Conveyor. Oscilveyor unit for conveying flakes, chips, grains, & other loose materials in bulk. Bulletin considers design & other exclusive features which increase efficiency & reduce wear. Gifford-Wood Co.

69. Industrial Packings. France Packing Co. catalog covers metallic packings, also asbestos Bakelite valve discs in all sizes & types. Cutaway views, tables, etc., included.

70. Centrifugal Air Washers. For those interested in recovery of fines from soaps, detergents, chemicals, & food products bulletin from Ducon Co. on centrifugal air washers. Capacities 500 to 40,000 cu.ft./min. Many advantages listed.

71. Cyclone. Called FR DorrClone unit is described in bulletin from Dorr-Oliver Inc. Physical characteristics, capacities & ranges of separation, operating results discussed. Adaptable to a variety of wet processing operations.

73. Valve Data. Cooper Alloy Corp. technical data booklet on stainless steel valve design, selection, maintenance & repair.

74. Propeller Type Meters. For measuring liquid flow. Bulletin from Builders-Providence, Inc. Propeloflo units are direct-reading, for metering water & other liquids.

75. Chemical Plants Engineering & Construction Services. Chemical Plants Div., Blaw-Knox Co. services described in booklet. Specialization is in fields of resins, plastics, fats & oils, related products.

77. Wire Strain Gages. Baldwin-Lima-Hamilton Corp. booklet on specifications for all sizes & types of bonded resistance wire strain gages, plus information on how to select a gage for specific test or routine conditions. For weighing, etc.

83. High Vacuum Pumps. Ranging from ¼ h.p. unit with displacement of 2 cu.ft./min. to 40 h.p. unit of 780 cu.ft./min., pumps are designed for low absolute pressures. Bulletin from New York Air Brake Co. gives pertinent details.

84. Chemical, Process & Power Plant Equipment. E. Moyer, Inc. Illustrated folder shows some end products, describes fabrication.

85. UPVC Pipe, Fittings & Tubing. Line fabricated from rigid unplasticized polyvinyl chloride is subject of folder from Easton Plastic Products, Inc. Tables on properties, pipe sizes, & resistance to listed chemicals.

86. Packingless, Self-Priming Centrifugal Pumps. La Bour Type CG pumps illustrated in bulletin. For both flooded suction & suction lift operation. May be used with over 10 ft. of positive head under specific conditions.

87. Proportioning Systems. Select-O-Weigh remote dial controlled weight selection system permits varying individual ingredient weights. Richardson Scale Co. bulletin.

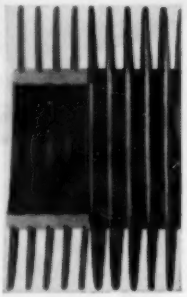
88. Butterfly Valves. New 4-page Builders-Providence bulletin on tight-closing rubber-seated butterfly valves. For use with fluodized solids, valves also meet all AWWA specifications. Of sturdy construction, easily operated units give long life & trouble-free performance in various installations.

89. Instrument Air Purifiers. For special use in systems supplying instrument air for pneumatic control systems. Line of R. P. Adams Co., Inc. cyclone separators & pipe line aftercoolers described in bulletin.

(Continued on page 64)

DEVELOPMENTS OF THE MONTH (Cont.)

138. New finned tubing surface for extreme high temperature heat transfer operations has been developed by Griscom-Russell Co., Massillon, Ohio. Intended for heat recovery from combustion gases, catalytic reaction gases, catalyst regeneration gases, G-R claims its new product solves the problems of resistance to oxidation, retention of high fin efficiencies, and permanent sealing and bonding of the fin to the tube. Possible uses are to heat liquids such as oils and molten metals.



G-R High Temperature K-Fin is made up of a dual metal helical fin brazed to the tube base. Fin has a copper interior for high heat conductivity, austenitic stainless steel cladding for oxidation resistance.

K-Fin can be used in convection heaters with inlet gas temperatures as high as 2600° F., heating liquids within the tubes to 1500° F.

Further information on specific applications can be obtained by circling number on Data post card.

139. To be sure you're using the right filter media use this test kit right on your production equipment.

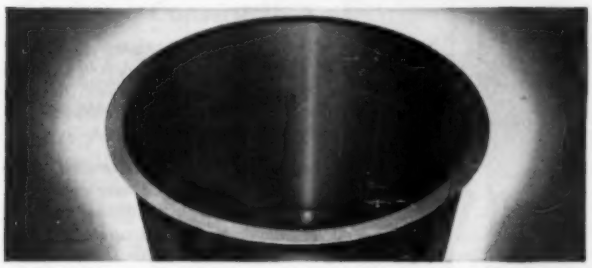
Eimco Corporation, Salt Lake City, offer this test kit that does the job on as many media as you can find—for a cost of only $5.

Heart of the test kit is Eimco's test filter leaf. Circular in construction, the leaf is one-tenth square foot, has a clamping band to fix the media sample to the testing surface. By connecting the leaf to a vacuum flask, and immersing the leaf in the sludge to be filtered, an easy and inexpensive test can be made under conditions closely simulating those found with existing or contemplated vacuum filters.

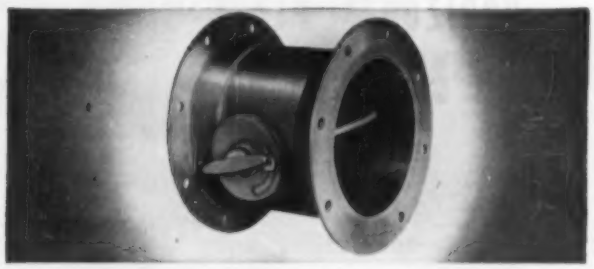
Specific test operation methods and calculations are outlined in Eimco's descriptive booklet accompanying the kit. In addition to the test leaf, the kit comes with samples of filter cloth in cotton, dynel, orlon, polyethylene, saran, and teflon, in various weaves and finishes. Further information can be had by encircling number 138 on Data post card.

HAVEG 1810 PVC SELF-SUPPORTING TANKS offer maximum chemical resistance and mechanical stability. Individually designed with a wide margin of safety. Welded-on structural shapes guard tanks against deflection.

FUME DUCT MADE FROM HAVEG 1810 PVC is both low cost and planned to meet your system's needs. Haveg's Engineering Department works with you for simplicity of design, ease in shipping, installing, and maintaining.



HAVEG ALSO LINES TANKS WITH HAVEG 1810 PVC. Steel, wood or concrete tanks can be made serviceable, completely corrosion-resistant, with a tightly bonded PVC lining. Haveg uses a special PVC laminate, can do work in the field.



HAVEG FABRICATES PVC into special butterfly dampers that can be installed in either round or rectangular fume duct. Dampers are instantly adjustable and locked in place, contain few parts. Let Haveg make special items for you.

NEW, LOW COST CORROSION-RESISTANT EQUIPMENT

...made by HAVEG from Haveg 1810 POLYVINYL CHLORIDE

TRADE MARK REG. U. S. PAT. OFF.

Haveg, America's first molder of plastic corrosion-resistant equipment, now adds rigid, unplasticized polyvinyl chloride equipment . . . supplied in new Haveg Grade 1810 . . . to its complete line. The same Haveg fabricating skill, the same Haveg practical knowledge of corrosion engineering backs your order. Briefly, here is what Haveg has to offer:

CUSTOM FABRICATION of self-supporting tanks, steel tanks lined with PVC, complete fume removal systems from hood to weather cap. Haveg also makes angles and channel sections, troughs, flanges, pans, trays and dippers in Haveg 1810 PVC.

A trained Haveg engineer surveys your requirements, furnishes test samples, price and design information . . . tells you if PVC can save you money, help you fight corrosion better.

A COMPLETE INVENTORY OF STANDARD PVC ITEMS, ready for prompt delivery:

Sheet stock: in your choice of 144 x 44", or 72 x 44" size, in thicknesses of 1/16, 1/8, 3/16 and 1/4"; and in 60 x 48" size — 3/8, 1/2, 3/4 and 1" thick.

Bar stock: ten foot lengths from 1/4 to 2" diameters.

Pipe: Furnished in 1/2 to 6" diameters in 10 and 20' random lengths. Variety of ends, including plain, threaded, screwed flanged, welded flanged. Plain and socket-end PVC pipe is also made for cemented, or cemented and welded, installation. Complete line of pipe fittings are fabricated and stocked by Haveg. Maximum recommended working pressure for all pipe sizes: 25 psi at 75°F.

CHEMICAL RESISTANCE RATINGS show that Haveg 1810 has excellent resistance to acid attack, extending even to strong oxidizing acids in high concentrations. Resistance to alkalies and alkaline salts, as well as neutral and acid salts is very broad. With many organic compounds Haveg 1810 is completely satisfactory. Write for complete data.

OPERATING TEMPERATURES for most Haveg 1810 equipment is conservatively rated at 150°F. Remember, the complete line of Haveg equipment, including items using phenolic, furan, epoxy, polyester resins, now covers a working temperature range from 150 to 360°F.

WRITE FOR NEW HAVEG 1810 CATALOG which describes this new construction material, gives sizes and corrosion resistance information. Haveg gives you: Custom PVC fabrication. Complete stocks of standard items. Experienced corrosion engineering service. Design, engineering and installation skill. Call the Haveg engineer listed!

ATLANTA, Exchange 3821 • CHICAGO 11, Delaware 7-6088
CINCINNATI 36, Sycamore 2600 • CLEVELAND 20, Washington 1-8700
DETROIT 39, Kenwood 1-1785 • HOUSTON 4, Jackson 6840
LOS ANGELES 14, Mutual 1105 • ST. LOUIS 17, Mission 5-1223
WESTFIELD, N. J., Westfield 2-7383

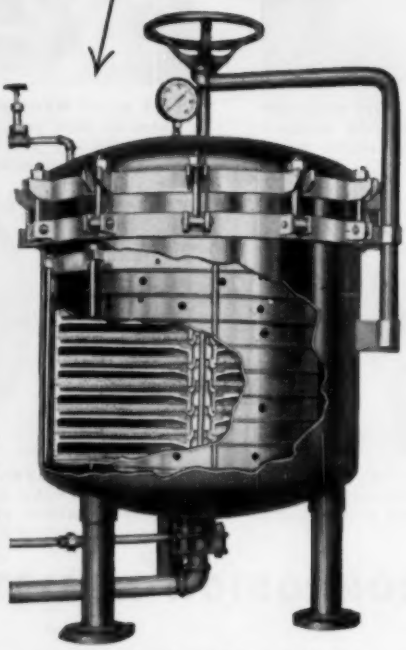
HAVEG CORPORATION
NEWARK 3, DELAWARE
TRADE MARK REG. U. S. PAT. OFF.
FACTORY: WILMINGTON 8, DEL. • Wilmington 3-8884
A SUBSIDIARY OF CONTINENTAL-DIAMOND FIBRE CO.

HIGH CAPACITY

versatile adaptability

. . . for all fine filtering

SPARKLER HORIZONTAL PLATE FILTERS



Versatile adaptability make this filter the logical choice of filtration engineers for difficult filtering problems.

Every filtering job usually presents an individual problem involving a combination of various kinds of screens, papers and filter aid. Frequently temperatures are encountered that call for a brine or steam jacketed tank. Linings; plastic or rubber may be needed, with tank and plate metals to fit the product such as mild steel, monel, nickel, stainless steel, bronze or Hastelloy. Constructed to meet ASME specifications when required.

All these structural and material combinations are easily achieved with the Sparkler Horizontal Plate filter.

No fibrous adhesive material is ever required to hold the filter cake on the horizontal plate. The cake is firmly supported on the plate with no danger of cracking or slipping even with a variation in pressure or a complete shutdown in the filtering operation. The patented Sparkler scavenger plate filters almost the last drop in a batch, and allows practically a complete recovery of the product.

Constant filtering quality is maintained from start to the end of the cycle, no break through can occur in a Sparkler Horizontal Plate filter.

What other filter can match this versatility and positive performance under a wide variation of filtering conditions?

Place your filtering problem in the hands of our filtration engineers. They have developed many successful methods of filtering difficult materials and may be able to prescribe a solution to your problem without wasteful experimentation.

Write Eric Anderson for personal attention

SPARKLER MANUFACTURING COMPANY

MUNDELEIN, ILL.

Canadian Plant, Galt, Ontario

European Plant, Amsterdam, Holland

For over a quarter of a century, engineers and manufacturers of a complete line of industrial filtration equipment.

equipment-

91. All-Plastic Pneumatic Instrument Tubing Harness. Ribbon construction, new harness assembly by Dekoron Div., Samuel Moore. Consists of 10 polyethylene tubes over which is extruded a web of elastomeric pvc .020 in. thick. Single tubes or groups may be peeled from harness without special tools. Eliminates metal tubing.

92. Armored Porcelain Centrifugal Pumps. General Ceramics Corp. Units have mechanical type seal, provide high reliability corrosion-resistant service with minimum of mantenance.

93. Cascade Cooler of Impervious Graphite. Falls Industries bulletin contains general description, discusses cooling of corrosives up to 700° F.

94. Process Oxygen Analyzer. Models C & C2P oxygen analyzers by Arnold O. Beckman, Inc. offer simple, convenient, low-cost unit for continuously measuring oxygen content of gas samples.

95. Surface Coating Defect Detector. Electrical device can be waved over conductive surfaces covered with protective coatings. Unit is non-destructive, accurate, & light weight, Tinker & Rasor.

96. Packingless Solenoid Valve. For higher temperature to (400° F.) & pressure process applications. Magnatrol Valve Corp. type S is normally closed, provides full port equal to nominal pipe size opening. Bronze.

100. Fabricating Titanium Tubing. Bulletin from Superior Tube Co. presents latest information and data on fabrication of unalloyed titanium tubing. Subjects covered are heat treating, pickling, welding, machining, etc. Applications, corrosion resistance, other points considered.

102. Pilot-Scale Filter. American Plant Equipment Co. unit permits determination of filterability rating of slurries on basis of pressure filtration data. Compressibility of filter cake taken into account.

103. Liquid-Sensing Unit. Air Associates, Inc. detector for sensing presence of liquid in fraction of second—absence in about five seconds. For operation in liquid temperature range of —319° F. to +200° F., with most liquids.

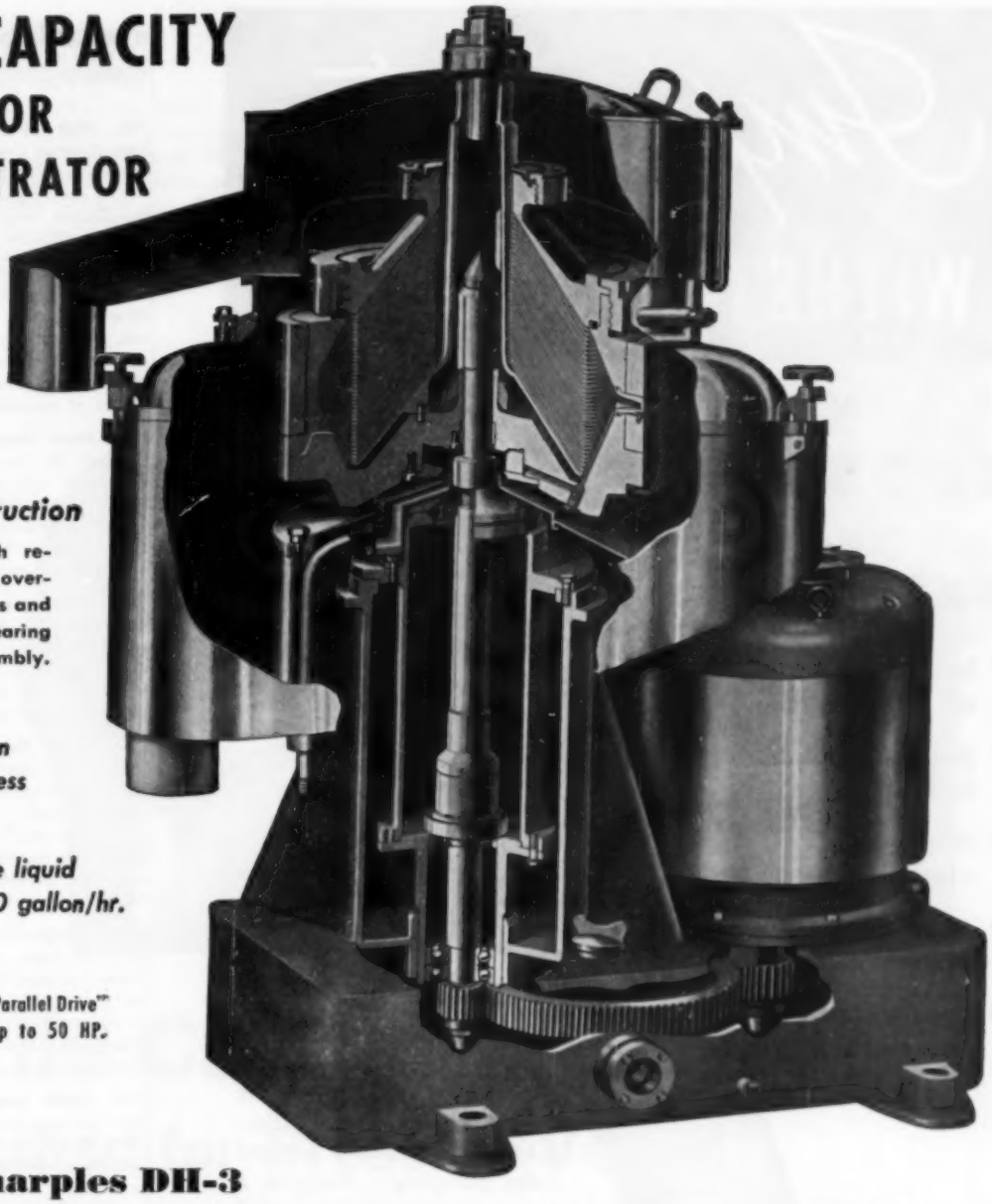
104. Inert Gas-Filled Motors. Allis-Chalmers' new line of motors for safe operation in hazardous gas-contaminated areas. Enclosures utilize air-to-water surface heat exchangers for removal of heat.

105. Pulverizer. Designed to insure product purity through easy cleaning, Mikro-Multi-D multi-grind pulverizer from Metals Disintegrating Co. Grinds in 4 to 20-mesh range with precise particle size control.

106. Teflon Filter Cloth. Data on controlled-pore-size filter cloth of Teflon for corrosive liquid & gas filtration compiled by Porous Plastic Filter Co. Two grades with 20 times tensile strength of solid Teflon. Chemical- & temperature-resistances listed.

(Continued on page 66)

HIGH CAPACITY SEPARATOR CONCENTRATOR



Completely Sanitary Construction

Cut-away view with re-cycle bowl. Note the over-sized discharge covers and heavy-duty triple-bearing suspension drive assembly.

The DH-3 can be furnished with even the frame of stainless steel.

Designed to handle liquid flows up to 18,000 gallon/hr.

Rugged, simple, spur gear "Parallel Drive" handles power loads up to 50 HP.

The New Sharples DH-3

For the Toughest Concentrating and Separating Jobs

Here is the centrifuge that's built in every detail for those many applications requiring higher than normal throughput capacity, and heavy-duty performance. The DH-3 stands in a class by itself . . . far above the well known smaller sized DH-2 Nozljector, and has already set new standards of centrifuge performance.

Bulletin 1276 is just off the press. Get the facts.

SHARPLES

THE SHARPLES CORPORATION
2300 WESTMORELAND STREET • PHILADELPHIA 40, PENNSYLVANIA
NEW YORK • PITTSBURGH • CLEVELAND • DETROIT • CHICAGO • NEW ORLEANS • SEATTLE • LOS ANGELES • SAN FRANCISCO • HOUSTON
Associated Companies and Representatives throughout the World

Imperwite

IMPERVIOUS GRAPHITE

WITHSTANDS 200 PSI

IN NEW

CROSS-BORE

HEAT

EXCHANGER

- immune to practically all corrosives
- possess truly uniform heat transfer
- features simplified cleaning
- undamaged by steam hammer
- unaffected by thermal shock

• Here is continuing tangible evidence of Falls Industries' leadership in the development of new and improved impervious graphite equipment. Other exclusives include rupture disks, pumping-x-changers, a new line of virtually leak-proof pumps, and carbon-impregnated graphite capable of withstanding temperatures to 5700°F. In addition, Falls Industries produces an extensive line of IMPERVITE equipment from complete HCI plants to machined components.

Call Falls for improved impervious graphite equipment.

WRITE TODAY FOR CATALOG

Falls Industries Inc.

31911 Aurora Road • Solon, Ohio • CH. 8-5357

Cleveland's Newest Industrial Suburb

equipment- (Cont.)

107. High Temperature Silicone Rubber. New General Electric Co. product remains flexible at 600° F. for 150 hrs. or longer during continuous exposure to peak of new temperature range. Class 700 material extends application of silicones.

108. Treated Cotton Filter Cloth fabricated from new type fabric offered by National Filter Media Corp. Resistant to many chemicals, mildew, shrinkage, & wrinkling. Good success obtained with rotary vacuum filters, plate & frame presses. Material available in variety of weaves.

109. Steam Generator uses #4 Fuel Oil. Compact 50 h.p. unit designed to burn economical #4 oil developed by Cyclotherm. Said to reduce fuel costs by as much as 30% compared to conventional fuels. Efficiency of 80% or better. Requires but 4 ft. 8¼ in. head room.

110. Vibrating screen. Allis-Chalmers Mfg. Co. bulletin on Aero-Vibe screen utilizing simplified two-bearing design with counterweight wheels & sturdy bolted construction. Handles feed to 4 in., can make separations from 1½ in. to 35 mesh.

111. Liquid Flow Totalizing Meter. For measuring liquids in hazardous atmospheres, an explosion-proof electricontact meter with electric shutoff. Consists of standard Niagara meter plus register containing electric switch for complete electrical circuit after passage of predetermined quantity of liquid through meter. Buffalo Meter Co.

114. Change Can Mixers. A new double planetary type stirrer action change can mixer developed by Charles Ross & Son Co., Inc. for thorough mixing of heavy materials in shortest time. Non-rotating can may be fitted with slide lever gate for emptying without removal from mixer.

115. Digital Computer. Bendix G-15 low cost general purpose electronic computer from Bendix Computer. Capable of solving lengthy & complex research & engineering problems.

116. Gage Illuminators. Efficient liquid level gage lighting units as redesigned by Jerguson Gage & Valve Co. Give even diffusion of light over length of gage glass without glare spots or blinding areas.

117. Bronze Valve. Said to be radically different, redesigned & engineered bronze valves from Lunkenheimer. Have two new elements; seating metal called Brinalloy hardened all through—resists wear & corrosion better than 500 Brinell stainless steel —also flat-seat design.

118. Ring-Jet Vacuum Pumps. Improved design of jet pump said to accomplish faster attainment of high vacuum—at pressures 10 to 500 microns. Capacity & fore-pressure tolerance make pump suitable for exhausting large vacuum systems. F. J. Stokes Machine Co.

121. Infrared Recording Spectrophotometer. For use in qualitative or quantitative analy-

(Continued on page 68)

Autoclave of Annealed Ductile Cast Iron... the first pressure vessel made by the Cooper-Bessemer Corp., Mt. Vernon, Ohio. Designed and approved for internal pressure of 350 p.s.i. at 300°F. with jacket pressure of 125 p.s.i. at 350°F. Oval manhole cover, blind flange, two agitators and thermometer well are also of annealed ductile cast iron to ASTM Spec. A-339-51-T. Body weight: 18,485 lb. Cover: 5,000 lb.

Ductile Cast Iron

Specified for Pressure Vessel

This 600 gallon autoclave of ductile cast iron is for use in a methylation process.

Unlike conventional flake graphite cast irons, ductile iron has a spheroidal graphic microstructure. That's why its mechanical properties are closer to those of steel than to those of gray iron.

Take a look at these test figures from heats used for the autoclave:

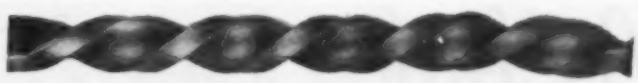
Ultimate tensile strength, p.s.i...64,500/69,700

Yield strength, p.s.i.....49,000/54,700

Elongation in 2"%.....19.5/23.5

Combining the process advantages of cast iron and the product advantages of steel, ductile cast iron is a logical material for process equipment.

See for yourself how this economical iron ... several times stronger than gray cast iron, and up to twelve times tougher . . . can help you. Send for a copy of "DUCTILE IRON, The Cast Iron THAT CAN BE BENT!" This booklet is yours for the asking. Write for it now.



ductile iron... the cast iron that can be twisted and bent

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

NO Interleakage Between Circuits

HERE!

When it is necessary, because of the nature of the fluids being handled, to obviate interleakage between the shell and tube circuits of a heat exchanger, our double tube sheet construction is the answer. Since independent tube sheets are employed for each circuit, and a void separates them, interleakage through a tube — tube sheet joint is impossible. In the outside packed exchanger illustrated, the shell side parts — shell, baffles, and inboard tube sheets — are of copper silicon alloy, while the outboard tube sheets and channels are of steel. The bi-metallic construction is carried even to the tubes which are 5/8" O.D. steel, clad with 1/16" copper wall.

Heat exchangers of this type are discussed, among others, in Whitlock Bulletin 250. Write for your copy today — and use it for reference in selecting your heat transfer equipment. The Whitlock Manufacturing Company, 97 South Street, West Hartford 10, Connecticut. In Canada: Darling Brothers, Ltd., Montreal.

Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

equipment-(Cont.)

ses of process streams, by Baird Associates, Inc. Unique floating-balance measuring system incorporated in double-beam instrument insures greater precision. Bulletin gives data.

122. Fire-Retardant Mastic. Fire safety in vapor-barrier mastic coatings available with Mastic 60-60 by Benjamin Foster Co. This non-asphalt mastic is listed by Underwriter's Labs as contributing almost no fuel, when dried, to fires arising near mastic-coated tanks, pipes, or other equipment.

123. Metal Detector. A low cost unit by Dings Electronics, Inc. is built for general industrial service. Said to be sensitive to all magnetic metals plus some non-magnetics, automatically signalling their presence.

124. Variable Speed Drive. Sterling Speed-Trol now equipped with electric Tachometer. Device includes a signal generator & speed indicator, with standard & special calibrations. Available with open, drip-proof & totally enclosed motors.

125. Pneumatic Relays. Large line offered by Powers Regulator Co. One device allows highest of two carrying air supply pressures to determine control pressure. Another acts as a check valve.

126. All-Teflon Spray Nozzles. Line of Teflon spray nozzles available from Bete Fog Nozzle Inc. Claimed to be clog and corrosion resistant with most sprays, long-wearing & inexpensive. Models are narrow angle 50° or wide angle 120° hollow cone spray pattern in flow rates 5 to 50 gal./min. Threaded with 3/8 or 1/2 in. male pipe thread.

127. Automatic Digital Controller. A new, compact, automatic unit suitable for batch mixing. Heart of American Electronic device is unit 7 x 10 x 8 in. with count capacity of 2,500. Adds & subtracts at rates to 20 decimal digits per second with accuracy of 0.04%.

128. Stainless Heat Exchangers. Stainless steel units intended for service with corrosive liquids or gases from Young Radiator Co. Available in single & multi-pass models in large range of sizes & capacities. Bulletin with design details.

129. Water Temperature Range Valve Lubricant. Multi-purpose Rockwell-Nordstrom No. 555 valve lubricant for wide range of service applications called the most important improvement in ten years.

132. Glass Shell & Tube Heat Exchanger. Production of Pyrex exchanger impervious to corrosion announced by Corning Glass Works. Main body of unit is 6 in. Pyrex glass pipe, while the 26 tubes are lengths of 3/4 in. thin wall Pyrex tubing supported every 6 in. by baffle plates.

133. Control Valve. The A. V. Cash Co. standard Type 10 is an improved, single seat, pilot-operated control valve with adjustable throttling range. Easy conversion possible from pressure reducing & regulating to a back pressure control valve by switch of control piping.

INDUSTRIAL NEWS

Construction is under way for a petrochemical plant to be operated by Escambia Bay Chemical Corporation between Milton and Pensacola in Santa Rosa County, Florida. Cost of the plant, including other facilities to be built later, will exceed $25,000,000.

Using natural gas as the principal raw material, the plant will produce as much as 250 tons of anhydrous ammonia per day, from which a daily output of some 220 tons of nitric acid, 275 to 350 tons of ammonium nitrate, and 200 tons of ammonium nitrate-ammonia fertilizer solutions may be developed.

Completion of construction work by Chemical Construction Corporation, New York, contractors, is scheduled for January, 1956. □

C. H. Wheeler Manufacturing Company has **sold its Fine Particles Grinding Department** to the Fluid Energy Processing and Equipment Company of Philadelphia. Nicholas N. Stephanoff, who has been manager of Wheeler's Fine Particles Department since 1946, will be president of the Fluid Energy firm. □

Stockpiling of lithium ore for the new American Lithium Chemicals, Inc., plant at San Antonio, Texas, began this month.

A shipment of nearly 11,000 tons of lepidolite (lithium) ore arrived at Corpus Christi, Texas, this week destined for the San Antonio plant. The ore came from the large lithium ore deposit in Southern Rhodesia, Africa, owned by Bikita Minerals (Private) Ltd.

Construction of the new lithium plant was begun last March. Processing of ore is scheduled to begin late this year. □

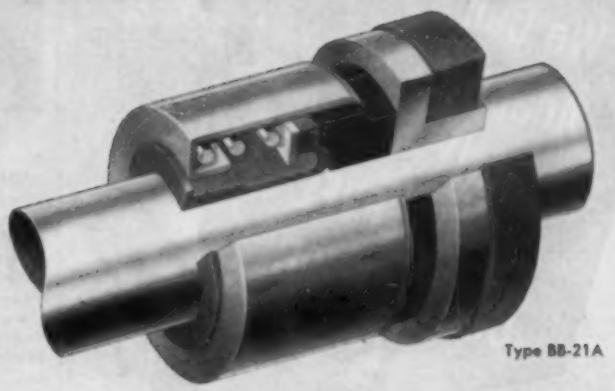
New $4 million pentaerythritol plant, with annual capacity for 25 million pounds of pentaerythritol, a key ingredient in the manufacture of modern weather-resistant, quick-drying paints, enamels, resins and other surface coatings, will be built by Heyden Chemical Corporation.

The new Heyden plant is now in the engineering stage, is expected to be in production by the end of 1956. □

Applications of radioactivity in the food and food processing industries is the subject of another industry-sponsored symposium.

Organized by Tracerlab, Inc., Boston, the symposium will bring together experts in the field who will present nearly every aspect of the subject. The meeting will be held for three days, October 19-21, 1955, at Sheraton Plaza Hotel in New York. □

GARLOCK MECHANIPAK SEAL



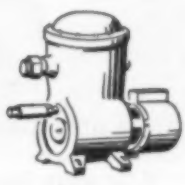
Type BB-21A

for Rotating Pump Shafts at pressures up to 150 p.s.i.

COMPLETELY ASSEMBLED — READY TO INSTALL

The Garlock BB-21A MECHANIPAK Seal, proven in service on thousands of water pumps, provides a low cost *leakless* seal.

IMPORTANT FEATURES



This MECHANIPAK Seal occupies a very small space—specifically designed for rotary pump shafts. It comes completely assembled, ready to install. Standard construction includes brass shell, brass washer and Buna-N bellows. Other materials available. Furnished for shafts from ⅜" to 3" diameters.

SAVE 3 WAYS

Customers tell us the MECHANIPAK Seal *pays for itself.* (1) Reduces maintenance costs (2) Absolutely no shaft wear (3) Cuts down time.

Get all the facts on this MECHANIPAK Seal. Write today for bulletin AD-150.

THE GARLOCK PACKING COMPANY, PALMYRA, N. Y.

Sales Offices and Warehouses: Baltimore, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, Los Angeles, New Orleans, New York City, Palmyra (N. Y.), Philadelphia, Pittsburgh, Portland (Oregon), Salt Lake City, San Francisco, St. Louis, Seattle, Spokane, Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ontario

GARLOCK

PACKINGS, GASKETS, OIL SEALS

MECHANICAL SEALS, RUBBER EXPANSION JOINTS

So SIMPLE
We Can
Adapt It
to ANY
LIQUID LEVEL
CONTROL JOB
A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.
MAGNETROL

AS DEPENDABLE AS MAGNETIC FORCE ITSELF

● No matter how specialized the liquid level control application, adapting Magnetrol to meet it presents no problem. Whether it's for high pressures, high temperatures, corrosive liquids or any other condition, a few "standard" modifications and the job is done! Operation is so simple no changes in basic design are needed. That's why Magnetrol "fits" practically any application — why "specials" are so often standard with us.

Because of the utter simplicity and dependability of its magnetic principle, Magnetrol has *infinite operating life.* There are no wearing parts to get out of order.

Magnetrols are available for controlling level changes from .0025-in. to 150-ft., with single or multi-stage switching. Our experienced engineering staff is at your service.

MAGNETROL, Inc.

WHY NOT MAIL THE COUPON — NOW

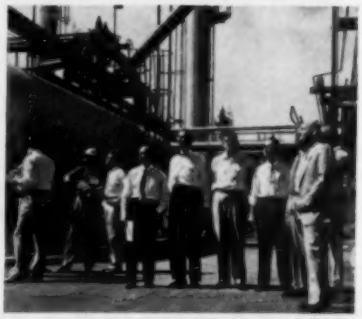
MAGNETROL, Inc., 2126 S. Marshall Blvd., Chicago 23, Illinois
Please send me catalog data and full information on Magnetrol Liquid Level Controls.
Name_____
Company_____
Address_____
City_____ Zone____ State____

HOUSTON

American Oil Company photos of groups visiting Texas City Refinery.

◄ A.I.Ch.E. Conventioners, after a 40-mile ride in air-conditioned buses complete with a commentary on surrounding area, arrive at Texas City refinery. Group was welcomed by plant officials. First stop on tour was the Ultraformer.

With American Oil Co. ► guide, S. N. Smith (third from left) shown l. to r. are Howard Rogers, Stillman—Ultraformer; W. H. Van Lohuizen, Consolidated Chemical Ind.; Smith; J. R. Moore, Monsanto; David Thomas, Pan-Am Southern; and T. J. Byrne, Pan-Am Southern.



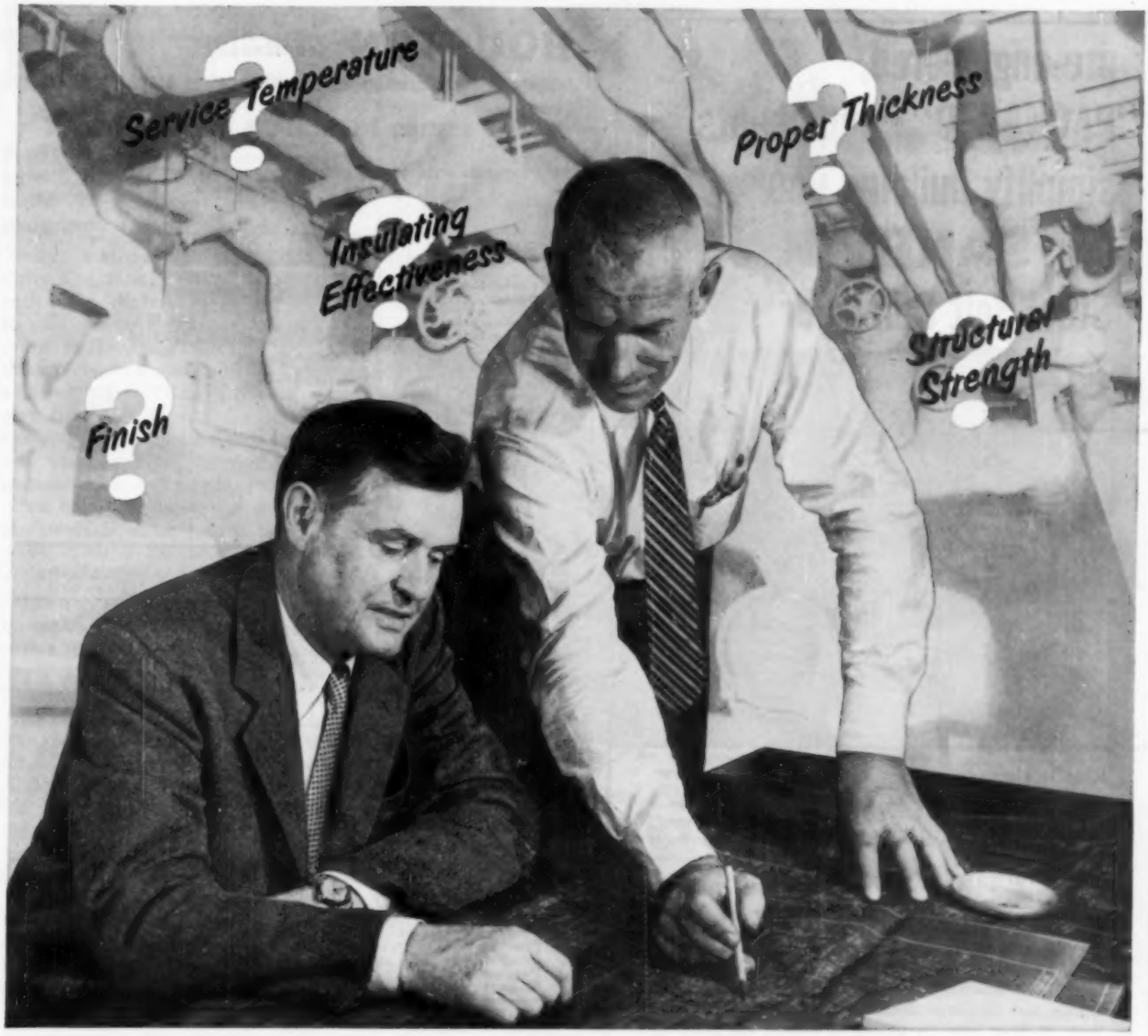
With American Oil Co. ► guide, H. L. Britton (fourth from right), shown l. to r. are D. E. Berger, Phillips Petroleum; P. H. Seaver, Badger Mfg.; W. R. Armstrong, Diamond Alkali; Britton; H. O. Weeren, Oak Ridge National Lab.; C. T. Barker, Koppers; and K. M. Elliott, Socony Mobil.

Group leaving Ultra- ► former. American Oil Co. guide, A. M. Haven. Shown l. to r. are J. A. Kordak, American Cyanamid; R. R. Ashley, Carbide & Carbon; R. G. Chenoweth, Carbide & Carbon; Haven; M. Gallagher, Pfizer; W. E. Lough, Pittsburgh Consolidated Coal; W. E. Voreck, Standard Oil (Indiana); T. B. Metcalfe, Shell Oil.

◄ Chief Operator explains control room features, nerve center of the process. Total catalytic cracking capacity of the refinery is 70,000 B/D.

◄ Leaving the plant, chemical engineers start through the 6-building Research & Development center. This part of visit emphasized areas of special interest such as research, engine, high pressure, and pilot plant laboratories.

In the air-conditioned ► laboratories. Shown l. to r. are R. A. Wilks, Standard Oil (Indiana); E. A. Shawd, Wyatt C. Hedrick Engineering Corp.; A. H. Seamster, Dow Chemical; F. M. Tennant, Dow Chemical; J. R. Tusson, Pan-Am Southern; D. L. Muffot, Standard Oil (Indiana); D. G. Hulett, Carbide & Carbon; R. G. Shuttleworth, Scientific Attache, South African Embassy, Washington, D. C.; American Oil guide Harold Murphree; and W. H. Clingman, American Oil.



Old hands at solving new insulation problems

Your **J-M Insulation Contractor** knows the answers that give you a better, more economical job

To be sure of getting the most efficient insulation for your plant or equipment, see the man with the world's most complete engineering and application service. He's your J-M Insulation Contractor who brings to every job the accumulation of Johns-Manville's 95 years' experience in the thermal insulation field.

J-M Insulation Engineers work hand in hand with J-M Insulation Contractors. Together they have achieved outstanding results with some of the most intricate insulation problems . . . of every type and size—in every industry.

J-M Insulation Contractors provide a complete selection of Johns-Manville quality materials. They will choose from their own stocks the best insulation for your conditions within the broad temperature range extending from minus 400F to plus 3000F.

Skilled application is a major contribution your J-M Insulation Contractor brings to every insulation job. His skilled mechanics have mastered the latest application techniques that assure you top-quality installation . . . give maximum operating economy and lower maintenance costs.

For undivided responsibility on all your insulation requirements, call your J-M Insulation Contractor. Write for the name of the one nearest you. Address Johns-Manville, Box 60, New York 16, New York. In Canada, Port Credit, Ontario.

JM PRODUCTS

Johns-Manville *first-in* **INSULATION**

MATERIALS · ENGINEERING · APPLICATION

pre-engineered, "PACKAGED" components simplify building your own SANDVIK Steel Belt Conveyor

Here is a money-saving way to build a new conveyor or convert an existing one with minimum time and effort.

One type of "Packaged" Assembly—Ready For Installation.

In addition to complete, custom-engineered steel belt conveyors, Sandvik supplies conveyor components in packaged unit assemblies. For example, you can buy the tension end assembly, drive end assembly, steel belt assembly and discharge devices from Sandvik and install them on your own supporting structure. The pre-engineered components simplify your engineering and facilitate successful operation.

A solid, conveying band of cold rolled, flat, carbon or stainless steel gives you these handling advantages.

- **Smooth, Hard, Impervious Surface**
- **Can Be Oiled To Facilitate Slide Handling**
- **Easy To Keep Clean**
- **High Load Capacity**
- **Long Service Life**
- **Can Be Fitted With Simple Scraper Discharge Devices**
- **Heat-Resistant**
- **Belt Can Be Of Any Length Or Width**

Write or phone for further information on "Pre-Engineered" components or on complete conveyors.

SANDVIK STEEL BELT CONVEYORS

Division of Sandvik Steel, Inc.
1702 Nevins Road, Fair Lawn, New Jersey
Tel. FAIR LAWN 4-6200
Branch Office: 230 N. Michigan Ave., Chicago 1, Ill., FRanklin 2-5638
IN CANADA: SANDVIK CANADIAN LTD. 5675 Royalmount Ave., Montreal 16, P. Q.

SANDVIK STEEL BELT CONVEYORS

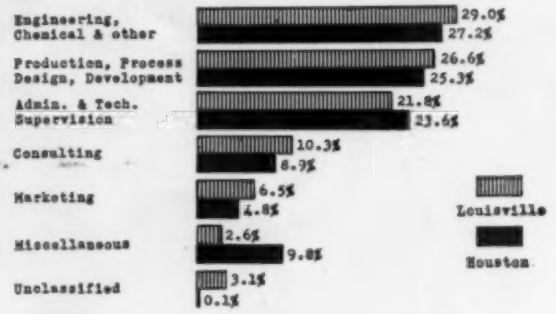
Manufacturers Of Steel Belt Conveyors For Over 40 Years

SS-108

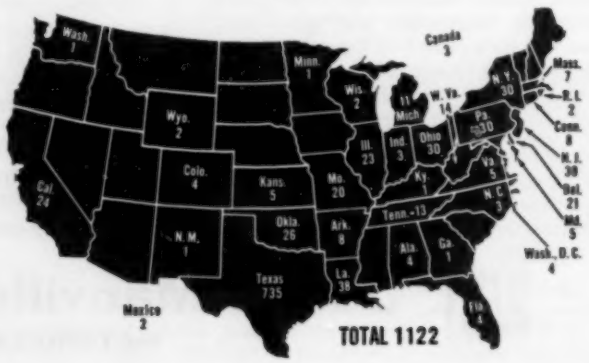
HOUSTON *(continued)*

Who comes to A. I. Ch. E. Meetings ?

three-fourths of the attendance comes from first three groups in the list below.



CLASSIFICATION SYSTEM	LOUISVILLE March '55	HOUSTON May '55
ENGINEERING, CHEMICAL & OTHER	277—29.0%	307—27.2%
Chemical Engineer	228	216
Engineer	7	31
Mech. Engineer	25	1
Chemist	11	33
Metallurgist	1	2
Technologist	5	24
PRODUCTION, PROCESS DESIGN, DEVELOPMENT	254—26.6%	285—25.3%
Design Engineer	22	30
Process Engineer	47	71
Devel. Engineer	85	68
Research Engineer	77	110
Nuclear Engineer	15	—
Control Engineer	7	9
Planning Engineer	1	7
ADMIN. & TECH. SUPERVISION	208—21.8%	266—23.6%
Corp. execs.	16	31
Chief engineer	38	51
Project engineer	58	28
Plant oper'ns mgr.	49	67
Plant oper'ns engr.	23	14
General mgr.	8	42
Personnel dir.	4	4
Manager	12	29
CONSULTING	98—10.3%	100—8.9%
Consult, teaching	77	58
Consult, non-teach.	10	18
Tech. dir.	5	15
Editor	6	9
MARKETING	62—6.5%	54—4.8%
Sales engineers	39	30
Prod. appl'ns engr.	16	19
Public relations	1	1
Marketers	6	4
MISCELLANEOUS	25—2.6%	110—9.8%
Student Ch. E.	21	107
Ch. E. in armed forces	3	2
Retired Ch. E.	1	1
UNCLASSIFIED	30—3.1%	7—0.1%
No class. spec.	30	7
Total	960—100%	1122—100%



Industry and Education

—CO-OPERATION IS THE KEY

Proof that industry and education are now walking hand in hand is seen in mushrooming programs of mutual aid.

Today, industry and the colleges and universities are aware of their value to each other, the mutual benefit that can be obtained through co-operation.

No further proof of this is needed than the myriad plans now in operation, and expanding. There is more than one way for industry and the colleges to work together, including work-education programs for students, university seminars for industry engineers, lectures, both businessmen at colleges and professors at factories, and many other ways. Two of the most basic methods are often in the news these days.

Industry's financial aid to education, through scholarships and fellowships with no strings attached is demonstrated by announcements from four leading chemical companies.

Monsanto will aid a total of 53 American colleges and universities during the school year of 1955-56. There will be 72 direct awards, 15 more than in 1954-55. As a testimony to Monsanto's belief in the necessity of liberal education, five of the colleges aided are straight liberal arts schools.

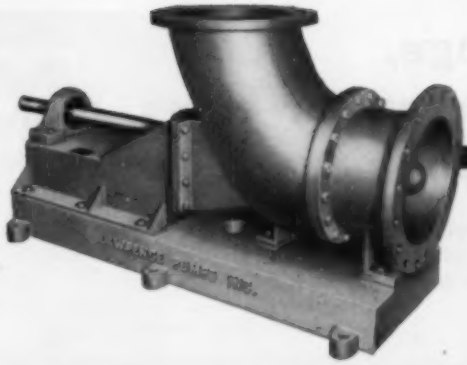
Allied Chemical will award 39 graduate fellowships in 29 educational institutions during 1955-56. Allied exercises no control over who is chosen and what the research project will be.

American Cyanamid will award 17 undergraduate scholarships and 14 graduate fellowships in chemistry and chemical engineering for 1955-56. Cyanamid's total program sends more than $600,000 to aid education each year.

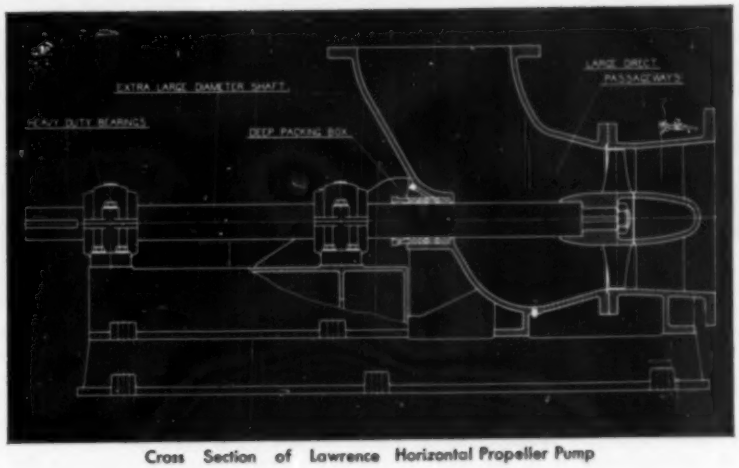
American Viscose will add five more institutions to its college-university aid program in 1955-56, bringing the total to 34.

All these programs emphasize the sciences and engineering sciences, but provision is made for non-technical fields.

The second basic type of industry-education cooperation is exemplified by Humble Oil's Lectures in Engineering Program. In 1955 the program will include four courses, taught by four visiting professors, and attended by 60 members of the company's Engineering and Mechanical Divisions at Baytown, Texas. The four subjects covered with the idea of bringing the engineers up to date are: "Piping Flexibility," "Corrosion," "Mechanical Vibrations," and "Soil Mechanics." □



Lawrence 24" Horizontal Circulating Pump of Nickel Alloy Construction



Cross Section of Lawrence Horizontal Propeller Pump

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Lawrence Propeller or Axial Flow Pumps are widely used to circulate large volumes of liquid or slurry against low heads as in evaporators, crystallizers, etc. This type of pump is particularly well adapted for circulating service because of its simplicity, high efficiency, and low first cost. The flow can be arranged in either direction and the casing turned to any position desired to serve as an elbow. The capacity can be closely regulated by varying the speed—very important in crystallization processes where a uniform velocity must be maintained.

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Write for Bulletin 203-6 for summary of acid and chemical pump data.

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Ion exchange, new areas for chem. eng., stream pollution . . .

. . . keep members and guests of the New Jersey Section busy at all-day meeting in Newark, May 10.

One entire session was devoted to the relatively new unit operation, ion exchange. Here, according to R. Kunin, Rohm & Haas, the development of stable, high capacity resins is leading to increased use of ion exchange in the chemical industry itself, although water treatment remains the major application.

l. to r. C. E. Geuther, J. H. Morris, R. D. Hoak, moderator, H. Heukelekian, and H. P. Purcell, chmn. of session on Control of Industrial Stream Pollution.

Perhaps major chemical industry application of ion exchange is in the fine chemical field, where it is used for deionization, ion-interchange, and adsorption-elution. In discussing this application of ion-exchange, J. Gillin, Merck, cited the use of adsorption-elution in the processing of antibiotics.

Turning to engineering details, R. E. Anderson, Dow, emphasized that while the scale-up of a fixed bed ion exchange operation is straightforward, the same is not true of continuous or semi-continuous processes. But Anderson pointed out that the sound application of established equilibrium and kinetic principles will be a big boost in overcoming the problem.

Although data are still meager, it has been shown that ion-exchange equilibrium is a function of the pressure-volume relationships and of the activity coefficients of the ions in the resin phase. At high solution concentrations the rate of an ion-exchange reaction is controlled by the rate of diffusion within the resin, while at low concentrations diffusion rates in the external solution become the dominant factor.

New Applications

Fermentation, jet propulsion, and nuclear engineering, are three new fields where the chemical engineer should shine in the future. E. L. Gaden, Columbia Univ., in calling for more chemical engineers in fermentation, pointed out that only the severe lack of kinetic and stoichiometric data has limited the application of chemical engineering in the process. This is being remedied.

l. to r. E. L. Gaden, L. R. Rapp, R. D. Toomey, chmn. of session on New Applications of Chemical Engineering, and T. B. Drew.

L. R. Rapp, Reaction Motors, Inc., insisted that the chemical engineer has been missing a bet in the jet propulsion field. He supported this by showing that the problems of a rocket motor are largely those of fluid flow, heat transfer, materials of construction, and combustion and ignition kinetics.

As for nuclear engineering, the problems of raw material processing, product purification, and waste disposal are similar to the same problems in a chemical plant. Even in the nuclear reactor the kinetics are fundamentally the same as in other chemical reactors and the rules of stoichiometry apply.

Pure Water

Emphasizing the growing need to conserve water, reuse all possible, R. D. Hoak, Mellon Institute, introduced the lively panel discussion on Control of Industrial Stream Pollution. With growing interest in the problem in Washington, A.I.Ch.E. in New Jersey joined with the Water Pollution Abatement Subcommittee of MCA to run this part of the program.

l. to r. D. W. Wood, chmn. of session on Ion Exchange, J. E. Anderson, R. Kunin, and J. Gillin.

Agreeing that industry will benefit in the long run by helping with the adoption of pollution control measures, the panel continued the discussion in their special areas of the problem: C. E. Guether, Du Pont, tackled the legal aspects; H. Heukelekian, Rutgers, discussed the biological points; and J. H. Morris, Merck, considered the part played by chemical engineering. □

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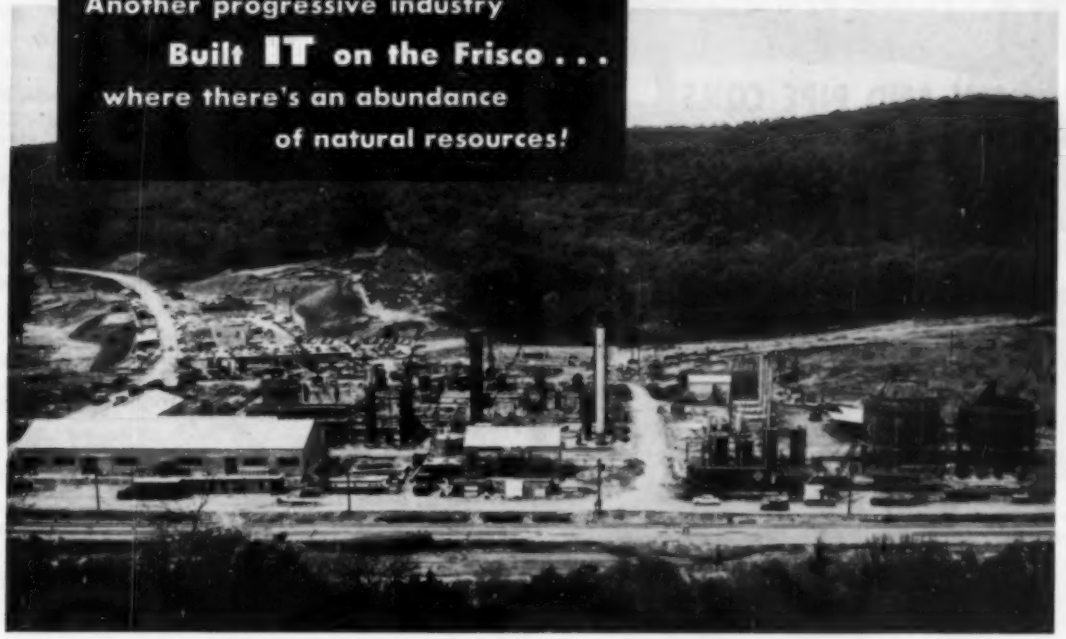

Water supply, natural resources, markets and rail facilities were primary considerations for the Mississippi River Chemical Company selecting this 4700-acre site near Crystal City, Mo. for its new $15 million petro-chemical plant for manufacturing nitrogen products, such as anhydrous ammonia, nitric acid and ammonium nitrate solutions and solids.

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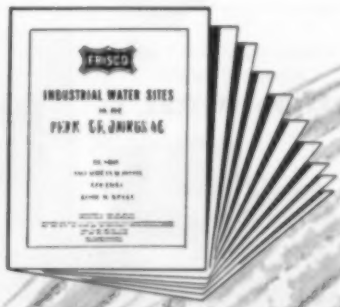

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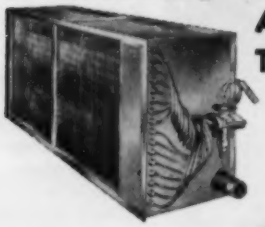

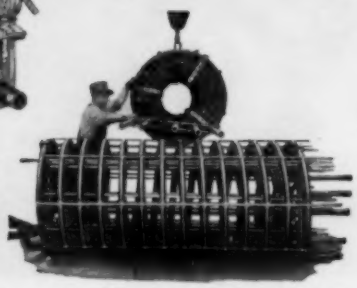

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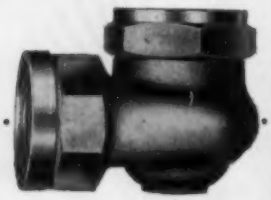

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The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on admissions.

These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members will receive careful consideration if received before August 15, 1955, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Adler, Stanley B., *Upper Montclair, N. J.*
Badawi, Hassan Ibrahim, *Gamalia, Cairo, Egypt*
Barnes, Brunner C., *Dallas, Tex.*
Bart, Roger, *Lakeland, Fla.*
Beach, James E., *Gibbstown, N. J.*
Bidez, Leo A., *Houston, Tex.*
Bowlzer, Lewis A., *New York, N. Y.*
Brown, Steven H., *Montclair, N. J.*
Callard, R. L., *Corning, N. Y.*
Cameron, Russell J., *Rifle, Colo.*
Class, James V., Jr., *South Pasadena, Calif.*
Curtist, Edgar O., Jr., *London W-1, England*
Dougan, L. D., *Sarnia, Ontario, Canada*
Draeger, Kenneth E., *Baton Rouge, La.*
Du Temple, Octave J., *Hinsdale, Ill.*
Grasley, Robert J., *China Lake, Calif.*
Hall, Robert E., *Cincinnati, Ohio*
Hubble, Henry H., *Richland, Wash.*
Hughes, George Kingsley, *South Charleston, W. Va.*
Hunt, Alfred W., *Tulsa, Okla.*
Jaske, Robert T., *Richland, Wash.*
Johnson, Frank B., *Baton Rouge, La.*
Jones, John B., Jr., *Rifle, Colo.*
Kalil, James, *Louisville, Ky.*
Kelly, T. B., Jr., *Corpus Christi, Tex.*
Krumbein, J. P., *Pensacola, Fla.*
Moore, Don A., *Wilmington, Del.*
Neat, Frank Urbane, *Baltimore 3, Md.*
Rose, Aaron, *St. Louis, Mo.*
Rueckert, Theodore C., *Louisville, Ky.*
Sage, Richard W., *Fanwood, N. J.*
Schreck, Robert T., *Lockport, Ill.*
Sullivan, J. B., Jr., *Birmingham, Ala.*
Walker, J. L., *Baytown, Tex.*
Wienert, F. O., *Niagara Falls, N. Y.*

Associate

Ambrogi, William P., *Philadelphia, Pa.*
Ambrose, John E., *Pittsburgh, Pa.*
Baltusis, Matthew A., *Alma, Mich.*
Barolak, Joseph, *Levittown, Pa.*
Barthelson, Norman A., *Wilmington, Del.*
Bauer, Harold E., Jr., *Peapack, N. J.*
Bellew, E. C., *El Dorado, Ark.*
Berkeley, F. Duncan, *New York, N. Y.*
Bloess, Juergen J., *Baytown, Tex.*
Boehmer, George J., *Massapequa Park, N. Y.*
Bolieau, Christopher W., *Knoxville, Tenn.*
Boyne, William J., *New Orleans, La.*
Brown, Donald R., *Argo, Ill.*
Cole, Halbert N., *San Francisco, Calif.*
Cook, Marshall W., *Richland, Wash.*
Coughlin, Paul I., *Orono, Me.*
Coulson, N. W., *Trona, Calif.*
Cunningham, Thomas L., *Lake Jackson, Tex.*
Dickinson, David F., *Fort Wayne, Ind.*
Donohoe, J. V., *Rochester, N. Y.*
Ericson, Kenneth R., *Cincinnati, Ohio*
Garland, Alton C., *East Sandwich, Mass.*
Gidley, John Lynn, *Houston, Tex.*
Goodwill, Marion J., *Shreveport, La.*
Granfors, Paul, *Cuyahoga Falls, Ohio*
Gretzinger, Thomas, *Texas City, Tex.*
Gronde, George H., *Wilmington, Del.*
Grossman, Seth S., *Chicago, Ill.*
Haynes, William P., *Pittsburgh, Pa.*
Hennig, R. J., *Ann Arbor, Mich.*
Keller, George J., *Arcadia, Calif.*
Knox, William G., *Pittsburgh, Pa.*
Kobett, Thomas E., *Kansas City, Mo.*
Lyon, George W., *Midland, Mich.*
Maassen, Clemens W., *Long Beach, Calif.*

McMillen, Richard L., *Wickliffe, Ohio*
Micklewright, Donald G., *Verona, Pa.*
Miller, Robert S., *Emeryville, Calif.*
Momany, George A., *Midland, Mich.*
Moon, George D., Jr., *Cincinnati, Ohio*
Mosher, D. R., *Minneapolis, Minn.*
Munson, Richard Eugene, *Hannibal, Mo.*
Neal, Hugh A., *Baton Rouge, La.*
Phillips, William M., *Birmingham, Ala.*
Putman, M. W., *Rifle, Col.*
Schulte, Louis O., *Alhambra, Calif.*
Schuman, Richard E., *Decatur, Ill.*
Sherwin, John C., *South San Francisco, Calif.*
Siedenstrang, F. A., *Borger, Tex.*
Solano, William, *McKeesport, Pa.*
Souther, Robert P., *Baytown, Tex.*
Strauss, Richard, *Cambridge, Mass.*
Taylor, Robert C., *El Dorado, Ark.*
Towers, Douglas W., *Fairview Park, Ohio*
Twardus, Edward V., *Parlin, N. J.*
Vallance, John M., *Mahwah, N. J.*
Warden, John H., *Port Arthur, Tex.*
Whiteacre, Robert W., III, *Verona, Pa.*
Willard, Ben A., *New Orleans, La.*
Worley, M. Steve, *Oklahoma City, Okla.*
Zuckerman, Leo, *Fry, Ariz.*

Affiliate

Annesser, Richard J., *Ann Arbor, Mich.*
Cockel, Lowell C., Jr., *Sierra Madre, Calif.*
Gillman, Joseph L., Jr., *Washington, D. C.*
Rowe, David L., *Norwood, Pa.*
St. Onge, R. A., *Ridgewood, N. J.*
Williams, Wilburn P., *Atlanta, Ga.*

(*Continued on page 73*)

Chemical engineering lecturing positions are open for Fullbright awards during the academic year 1956-57. Deadline for applications is October 1, 1955.

Positions are in the following institutions: Technical University of Denmark; University of Oslo.

A position in Mineral Engineering is open at the Institutes of Technology, Graz and Vienna, Austria.

Japan desires a lecturer in chemical engineering but the institution has not been named as yet, and Great Britain has not announced its needs for the 1956-57 academic year. □

A grant of $26,000 by the Rockefeller Foundation to assist the participation of foreign scientists and engineers in the World Symposium on Applied Solar Energy next November has been given to Stanford Research Institute.

The funds will enable more than 25 foreign scientists to take part in meetings scheduled for November 1-4 in Phoenix and a special preliminary conference at the University of Arizona, Tucson, October 31 and November 1. □

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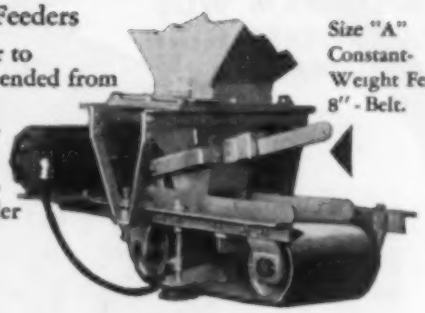

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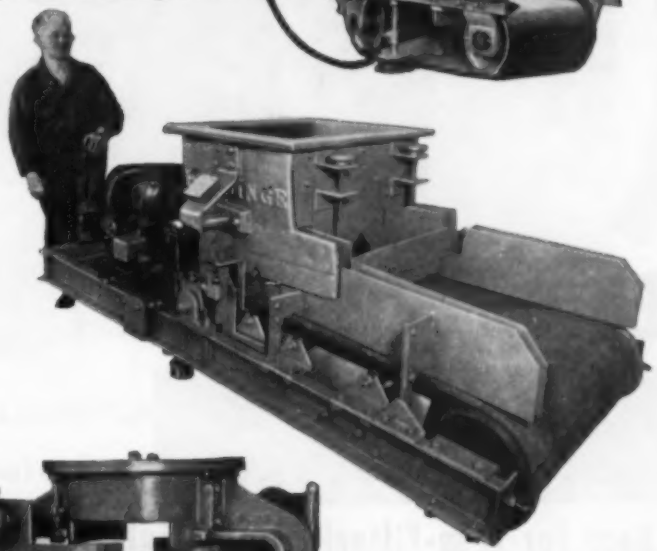

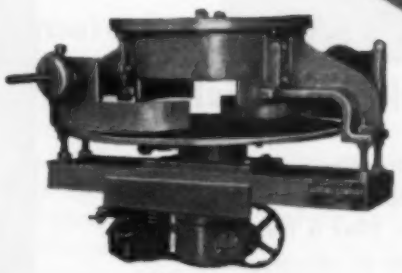

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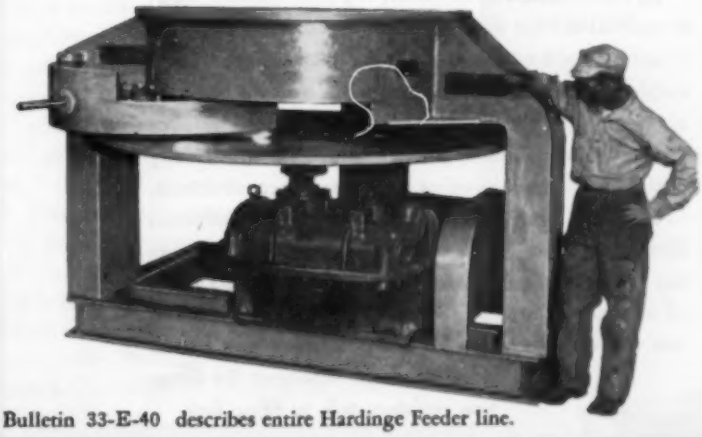

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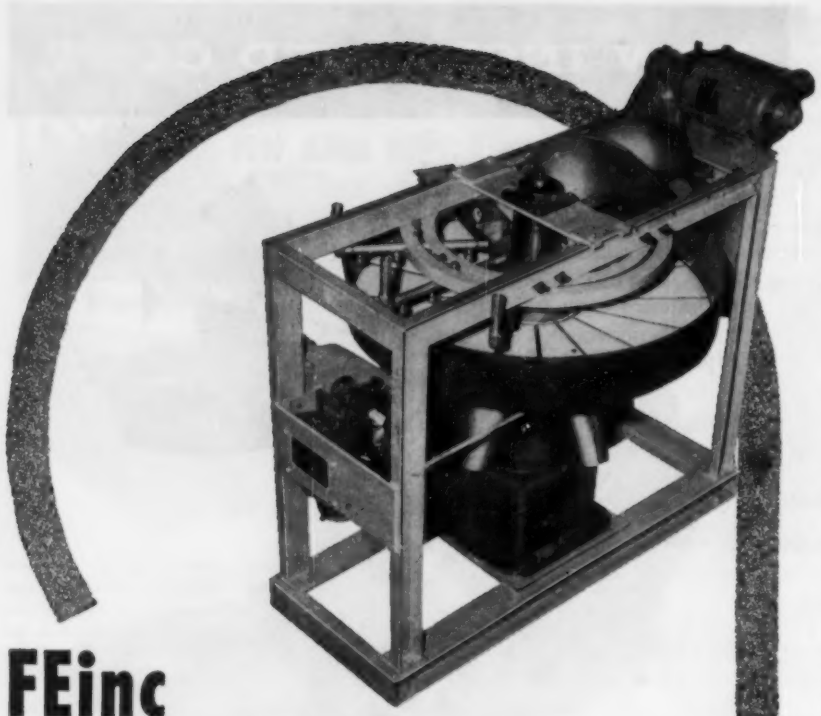

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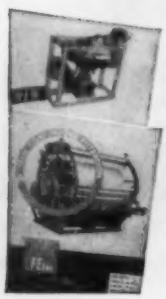

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INSTITUTIONAL NEWS

A new department of engineering economics research has been established at Armour Research Foundation, Chicago, to meet an increased need for combined scientific, engineering and economic background in solving many industrial problems.

Typical studies to be undertaken are market analyses of technical equipment or services, new applications for existing materials, technical and economic evaluation of products, and area development. □

Increased demand for knowledge of markets and business conditions, has led Midwest Research Institute, Kansas City, Missouri, to form an Industrial Economics Division. The division is the outgrowth of a group at the Institute which was formerly called Engineering Economics. □

National Science Foundation grants for the quarter ending March 31, 1955 have been awarded to four chemical engineers.

E. J. Henley, Department of Chemical Engineering, Columbia University, receives $7,000 for a proposed 18 months work on "Ionization Patterns in Condensed Systems."

L. S. Kowalczyk, Department of Chemical Engineering, University of Detroit, received $3,500 for one years work on "Thermal Conductivity of Mesomorphic Liquids."

S. G. Bankoff, Department of Chemical Enginering, Rose Polytechnic Institute, gets $7,600 for 18 months on "Equilibrium Bubble Contact Angles as Related to Pool Boiling Heat Transfer."

H. V. Fairbanks, Department of Chemical Engineering, West Virginia University, is awarded $9,100 for 2 years work on the "Effect of Ultrasonics Upon Dispersion Hardening of Metals." □

A $1,500 Allied Chemical and Dye Corporation Fellowship in Chemical Engineering for 1955-56 has gone to a Yale graduate student.

James J. Carberry will use the followship for his final year of work at Yale toward the Ph.D. degree in chemical engineering. Carberry received his B.S. and M.S. degrees from the University of Notre Dame. □

A $2,000 grant has been awarded by the Research Corporation of New York to G. E. Estok, associate professor at Texas Tech, to support his study of the behavior of molecules in different environments. □

To aid outstanding students in chemical engineering and chemistry, a scholarship fund in memory of the late H. K. Benson has been established at the University of Washington. □

NUCLEAR NEWS

An atomic reactor design which could remove many obstacles to the use of atomic power plants in airplanes, locomotives and ships, has been proposed by E. A. Luebke, physicist, and L. B. Vandenberg, engineer, members of General Electric's Knolls Atomic Power Laboratory at Schenectady.

The design is less than half the weight per horsepower of conventional atomic reactors, eliminates many moving parts that are standard in such equipment.

A liquid metal reactor, most of the weight and bulk was removed in the GE design by "nesting" the reactor inside a cylindrical heat exchanger, eliminating the separate heat exchanger used to convert water into steam to drive turbine generators. □

This is all made possible by using electricity developed by temperature differences in the heat exchanger to pump the liquid metal coolant.

The economic and management side of industrial atomic energy will be the special field of a new management consulting service established by Arthur D. Little, Inc., Cambridge, Mass.

Primary objective of the non-technical service is to aid management men in defining and developing opportunities for profitable participation or expansion in industrial atomic energy. □

The development of complete reactor systems and components will be the first job of American Radiator & Standard Sanitary Corporation's new Atomic Energy Division. □

New Nuclear Engineering & Manufacturing Division will take over all North American Aviation's extensive work in the field of commercial atomic energy. □

Full industry-scale salaries while working for a doctorate in nuclear power will soon be possible under a plan worked out between Westinghouse Electric and the University of Pittsburgh. Top-notch college graduates will spend part of their time studying at the University and part working for Westinghouse in the initial phase. Following this phase, graduates become eligible for educational-leave from the company and return to school to study full-time for their doctorate. □

Two semester Master's degree program in Nuclear Engineering is being offered by the University of California Radiation Laboratory at Berkeley and Livermore. Attention will be focused on analysis, design, performance prediction, and cost of nuclear power systems. □

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December 12 through 16

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Cleveland Public Auditorium

December 10 through 16

UNDER the coordination of the Engineers Joint Council, nuclear scientists and engineers of 24 industrial and scientific groups and engineering societies will convene at the Nuclear Congress in Cleveland for five historic days beginning December 12. They will hear and discuss more than 290 significant papers presented by leading atomic experts on new developments in the application of nuclear energy to industrial and other uses.

Over 45 of these papers will be presented under the sponsorship of the A.I.Ch.E. These papers will deal with subjects of interest to every Chemical Engineer concerned with nuclear energy. In addition, the Congress will give every A.I.Ch.E. member the rare opportunity of meeting and talking with the nation's foremost nuclear authorities in allied fields of engineering.

Make your plans to attend the Nuclear Congress *now* because accommodations will soon be at a premium.

FOR the first time, A.I.Ch.E. members can see the newest and most important product developments in nuclear science under one roof . . . as well as a nuclear reactor in operation right on the floor . . . at the ATOMIC Exposition. Running concurrently with the Nuclear Congress, under the sponsorship of your A.I.Ch.E., this great exposition will have on display the latest products of approximately 100 manufacturers.

The exposition will open Saturday, December 10, two days in advance of the Congress. Here is your best chance to evaluate new products and developments, get the facts first hand on application data, and talk shop with your contemporaries.

Your A.I.Ch.E. membership is your admission ticket. Don't miss this great show of nuclear energy in action!

Previewed in the October Issue of

Chemical Engineering Progress

Note to Advertisers

Whether or not you will exhibit at the ATOMIC Exposition, be sure you're in the October issue of CEP . . . the publication that will preview both the Nuclear Congress *and* the Exposition. This is the time to tell your product story to the chemical engineers who specify and buy in the nuclear energy market.

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Concurrent first International Atomic Exposition will back up theoretical sessions with displayed equipment and know-how.

U. S. and foreign engineers, scientists and industrial representatives from 24 business and technical societies, 16 universities, 13 Government bureaus and AEC contractors, and 34 major U. S. industrial corporations will be at Cleveland to deliver nearly 300 papers in 50 sessions. Papers will cover practically every phase of peace-time uses of atomic energy and its by-products.

Sponsors include a total of 21 professional societies.

During the entire week of technical sessions the Exposition, sponsored by A.I.Ch.E., will be open for those who want to see what leading U. S. and foreign companies are doing to harness the atom for industry. Much of the special equipment developed for peacetime use of atomic energy will be seeing the light of day for the first time.

In addition to U. S. developments, the Congress will cover atomic progress in Canada, Britain, Australia, and South Africa.

Prominent among the 50 session topics are the "where and how" of atomic power plants with emphasis on safety and selection of site; radiation hazards and their controls; the varied proposed power plant types; atomic reactors for research purposes and radiation laboratories; radioisotopes and tracer techniques for industry, medicine and agriculture.

Reactor models of the latest design will be shown in the Exposition—some still undergoing last minute design changes.

Since many of the conventional materials do not have the properties essential for use in radioactive installations, newly developed alloys and materials possessing unusual properties will get a lot of attention.

The Exposition in Cleveland's Public Auditorium, where many of the technical sessions will also be held, will be open to the general public on December 10 and 11 and in the evenings December 12 through 16. Registrants to the Congress will be admitted to the Exposition at any time. □

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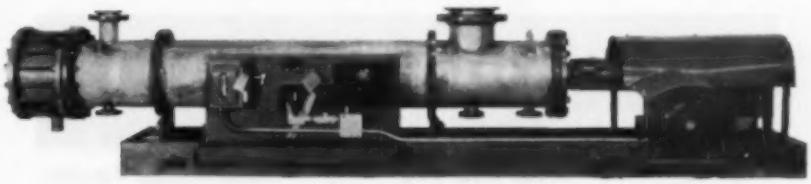

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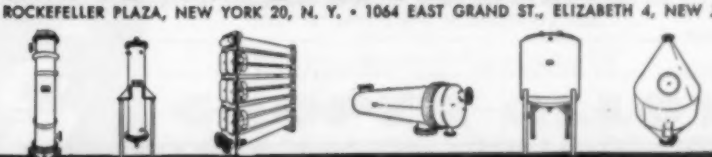

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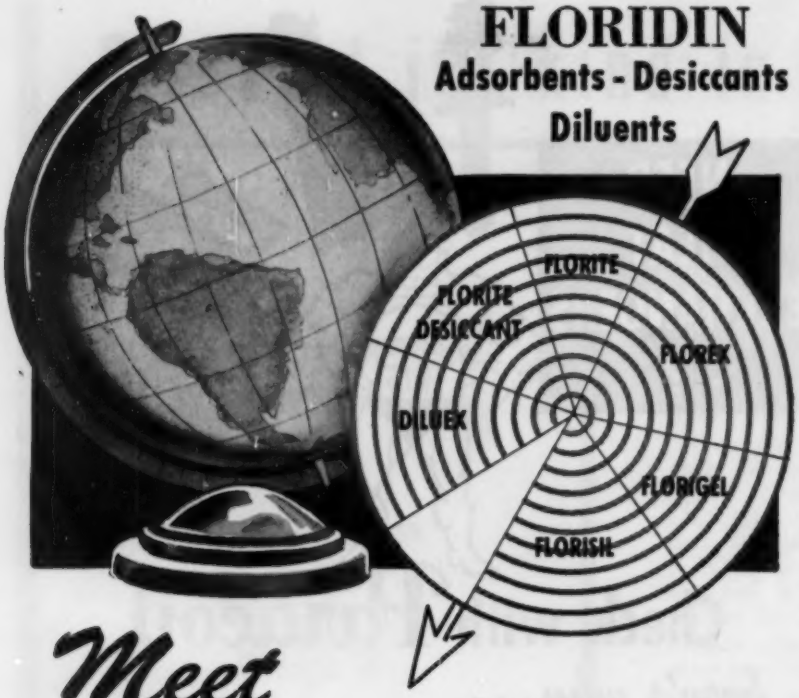

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News of the Field
FROM LOCAL SECTIONS

Baltimore, Md. Public education and enlightenment on the nature of chemicals, their safety, their beneficial contributions to mankind, and their basic importance to our industrial economy and national defense, should be the job of every chemist, chemical engineer and chemical organization.

Speaking to the April 19 meeting of the Maryland Section, R. L. Taylor, asst. director of public relations, Olin Mathieson Chemical, went on to say that the chemical engineer should seize every opportunity he can to enlighten public audiences on the results and potentialities of new scientific and technological research and development.

Despite the fact that chemical technology has wrought changes in the physical world today equal to any in the course of history, the public is still to a large degree ignorant of what chemical engineers do, how they work, who they are. Here is where the chemical engineer can do his part.

National organizations like A.I.Ch.E. and ACS are all doing a good job, making much headway in the direction of public enlightenment in chemical matters, but a far greater potential lies in the voices and pens of all chemical engineers and chemists.

In defining the true work of public relations in industry, the work of formal public relations departments, Taylor divided the job into two basic parts. (1) To make sure that the policies of the company are clearly in the public interest. (2) To see that facts about the company, its activities, its policies, its products, are communicated to the various publics as a basis upon which a favorable opinion can be formed.

The remainder of Taylor's talk covered popular misconceptions of public relations as either simple publicity, sales promotion, a first-aid tool for the emergencies of bad relations, and a catch-all department for all the jobs no one else wants to do. Public relations, he emphasized, is none of these. It is a tool whereby management can be helped to always put its best foot forward, and inform its many publics of just what and why that best foot is important to them.

—C. G. SCHMITZ

Atlanta, Ga. Market research, market development, and methods of obtaining market information, with some interesting case histories, formed the subject of C. A. Stokes, Godfrey L. Cabot, Inc., at the April meeting of the Atlanta Section.

—H. H. SINEATH

Cleveland, Ohio. Industrial research and development has become an essential cost of competitive business enterprise. This was the major point of H. B. Warner, Goodrich Chemical, in his speech at the March 22 meeting of the Cleveland Section.

Research and development has become an organized operation with its own special problems, new techniques developed, and developing, to improve its productivity and operation efficiency.

The stability of our present economy, and the continued growth of our material standard of living is based on change, Warner emphasized. Industrial research and development has the task of guiding this change so that it will provide products of better value for less money.

All development projects are considered from eight viewpoints: technical appraisal, economic appraisal, raw material position, market survey, commercial appraisal, patent appraisal, estimated cost of research and development, and estimated timetable to complete project.

—J. L. MILLER

New Orleans, La. In general the engineer has more than held his own as far as salary levels are concerned over the last twenty years, said J. W. Bertetti, Pan-American Southern, speaking on "The Engineer—His Salary and His Job" to the April 12 joint meeting of the New Orleans Section and the Tulane Student Chapter.

Bertetti used graphs and figures to back up his statement, show that engineers are maintaining their position in the professional world.

—E. R. COUSINS

Charleston, W. Va. A man is not a real chemical engineer if he deals only with chemicals and equipment, stated A. G. Stones, Charleston lawyer, talking on his "Impression of a Chemical Engineer" at the annual dinner meeting of the Charleston Section on May 20.

Harmonious relations with people are of equal importance, Stone said, because that is the basis of civilization.

—R. W. TIMMERMAN

Southern California. Estersils have many advantages over soaps as grease thickeners in the view of N. D. Lawson, Du Pont, who presented his ideas on "New Approaches to Additives for Fuels and Lubricants" to the May 17 meeting of the Southern California Section.

Lawson went on to discuss the performance of lube oil detergents under low and moderate temperature conditions, the high temperature stability of JP-4 jet fuels, and the effects of various additives.

—F. G. SAWYER

(*Continued on page 86*)

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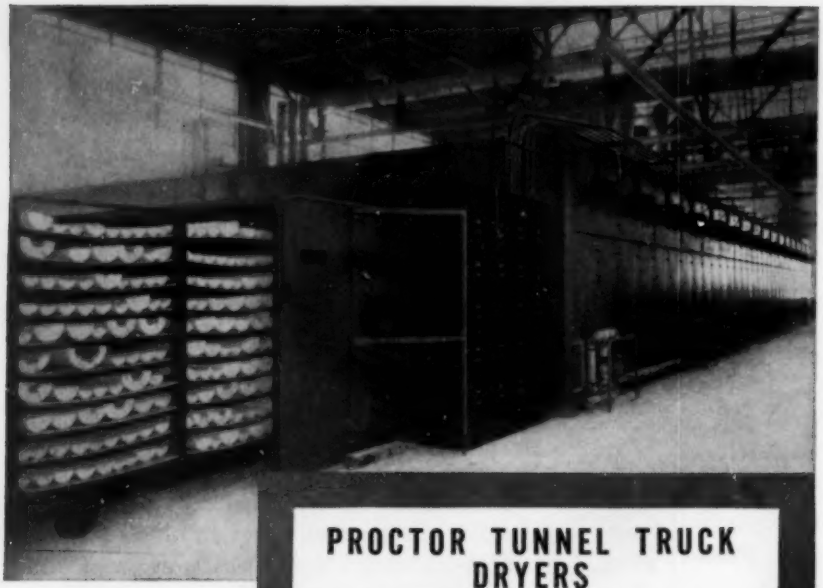

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LETTER *transmitted by* M. J. KELLY *to Professional Societies*

June 8, 1955

United Engineering Trustees, Inc.
American Society of Civil Engineers
American Institute of Mining and Metallurgical Engineers
The American Society of Mechanical Engineers
American Institute of Electrical Engineers
American Institute of Chemical Engineers

Gentlemen:

We, the undersigned, as members of academic and industrial organizations that are concerned with the welfare of your Societies, are addressing you collectively concerning the choice of a new headquarters for your organizations. While some of us already have indicated a preference for one city and others of us for another, we are agreed that the fundamental desirability of approaching this matter on a national rather than a local basis transcends our personal preferences.

The progress of our highly industrialized society is dependent on its scientific and technologic strength. A major portion of the technology upon which our industries depend is encompassed within the combined scope of your Societies, and a large portion of the professional men contributing to the technology and its practice are members of one or more of your organizations. It is because of the important place in our society that you occupy that we are concerning ourselves with the choice of a location for your new headquarters.

We understand that your present building at 33 West 39th Street, New York City, which is now some fifty years old, has become grossly inadequate for your operations and that you have been planning for some time a new headquarters building adequate for present and future needs. With the use of the funds of your depreciation reserve and the funds to be realized from the sale of the present property, you will require about $2.5 million of new funds. As an inducement to locate the headquarters in their cities, at least three have indicated that local organizations will contribute generously to your building fund. The suggested contributions, we understand, have ranged from approximately $500,000 to $1.5 million.

While this evidence of civic pride is praiseworthy, we believe the matter of local contributions is of secondary importance in your choice of location. We suggest rather that the long range interest of the Societies in serving their professions and the nation are paramount, and that maximum effectiveness of your operations is of controlling importance.

Most industries of the country benefit directly from the technologies included in your organizations. We are sure they will contribute generously to your building funds if your location is chosen on the broad-gauged basis suggested. If such a choice is made, a group of the undersigned will organize a large national committee, representing all sections, all technologies in your Societies, and a variety of industries, to conduct a nationwide drive for funds.

We understand that several studies of location have been made. Perhaps they have not been sufficiently coordinated and integrated. We respectfully suggest that a competent and independent management or engineering firm be employed to coordinate and evaluate these studies and to make additional examinations as required, and when the integrated studies are available, that you make your selection on the basis we have suggested.

As you no doubt realize, many large industries employ outside counsel for studies to

a **CEP** *interview*

with MERVIN J. KELLY

President
Bell Telephone Laboratories

on NEW PROPOSAL FOR ENGINEERING CENTER

Q. Mr. Kelly, the proposal signed by 21 leaders of industry and engineering education is of outstanding interest to our readers. We would like to have you tell us about background.

A. The letter itself presents, I believe, a full statement of the views of those who signed it, and of their proposal to the societies. Of course, no such document springs into being spontaneously. The situation in which the five societies and the United Engineering Trustees found themselves in–as their quest developed for a new home for their headquarters–was such that a new approach was sorely needed. I suppose I might be rightly termed the "initiator."

Q. Would you elaborate on your role as "initiator?"

A. First, let me emphasize, the situation required a new approach. The approach should come from a responsible source . . . interested primarily in the long-range well-being of the societies . . . willing to subordinate local interests to the broader interests of the societies and of their contributions to the nation. An approach based on such philosophy would have enthusiastic acceptance of men of the type and responsibilities of those who did sign it. In such a favorable climate the role of initiator is minor though, of course, essential.

Q. When did your interests begin to crystallize?

A. A few months ago, I became a member of the Committee of the Mayor of New York City for presenting to the societies the case of New York as the home of the headquarters and, if necessary, to enlist local financial support. In the early days of these Committee activities, I first learned of the situation–not only at Committee meetings but also from discussions with many individuals in the societies. Among these were presidents, past presidents and directors of some of the interested societies. I found most of them concerned with the course of events. With the keen competition between cities, they feared that no matter which was finally chosen, damage would result to the long-range strength of the societies, and to their integration. This damage could not be accurately assessed and there was a range of views as to its possible magnitude. In general, I shared these views. I then discussed the situation with a few of those who later became signatories. Out of these discussions came the proposal of our letter.

Q. How was the proposal received among those solicited for signatures?

A. After the decision by a few of the signatories that such an approach should be made to the societies, a draft almost identical to the final letter was made. Some twenty-seven men were then contacted either by a personal interview or by sending the draft of the letter followed by telephone discussion. Of the twenty-seven approached, twenty joined me in signing. All of those who signed were enthusiastic for the approach. The industrial signatories recognized the large interest of industry in the societies and the responsibility of industry for aid in financing the new headquarters. A few of them stipulated, because of their work loads, that they could not be active in any later drive for funds but indicated that they would recommend contributions from the corporations of which they are officers. Of those who did not sign, only two disapproved of the project, the other five while approving gave full explanation of their inability to join in the proposal. The high level of acceptance of the soundness of the proposal was most heartening.

Q. Is there anything that you would like to add, perhaps for emphasis, about the content of the letter?

A. Nothing additional occurs to me. However, I might emphasize one point. If the societies decide to accept our proposal, it is most important that a competent, unbiased, and objective study of location be made. I am confident that generous financial support for the new headquarters with wide participation by industry will be obtained, whatever location is chosen for the headquarters, if it is so selected. Many of the signatories, including myself, are prepared to follow through with the organization of a national campaign by friends of the societies for financial support, and I am sure that the response will be generous.

Since our discussion will be reported in the official publication of the Chemical Enginers, I might express my pleasure in finding that the Chemical Engineers are joining with the four other societies in the new headquarters. The integration of the major engineering societies into some kind of organization—no matter how loose—has great value. This closer association makes possible, where necessary, a united front and united planning in national interest.

Finally, the societies should take pride in the evidence that this letter provides of the great interest of typical leaders of industry and engineering education in the welfare of the societies.

---

determine the best location for new units of their business. There are several organizations that are competent to make such studies. We suggest that you select from among them one for the task. Some of us who are signing this letter will provide the funds to cover its cost.

While we are not now in a position to guarantee the amount of the subscriptions for your building fund, we are confident that the amount required beyond your resources can be raised through a campaign of the scope we have indicated. We assure you that a well organized, diligent and competent effort will be made and continued until the required sum is available, which we understand is approximately $2.5 million. Respectfully submitted,

J. F. Bell, Chm., Com. on Finance and Technological Progress, General Mills, Minneapolis, Minn.
D. W. Bronk, pres., National Academy of Sciences, Washington, D. C.
R. J. Cordiner, pres., General Electric Co., New York, N. Y.
J. Creese, pres., Drexel Institute of Technology, Philadelphia, Pa.
J. H. Davis, pres., Stevens Institute of Technology, Hoboken, N. J.
L. A. DuBridge, pres., Calif. Inst. of Tech., Pasadena, Calif.
T. K. Glennan, pres., Case Inst., Cleveland, O.
E. G. Grace, chm. of the Bd., Bethlehem Steel, New York, N. Y.
C. H. Greenewalt, pres., Dupont, Wilmington, Del.
W. H. Harrison, pres., International Tel. and Tel., New York, N. Y.
L. W. Houston, pres., Rensselaer Polytech. Inst., Troy, N. Y.
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K. T. Keller, ch. of the Bd., Chrysler Corp., Detroit, Mich.
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A.I.Ch.E. News of the Field
FROM LOCAL SECTIONS

(*Continued from page* 83)

Minneapolis, Minn. Presentation of an award for the best solution submitted to the National A.I.Ch.E. Student Problem Contest from the Twin Cities area, highlighted the May 19 meeting of the Twin Cities Section. The unique prize went to J. J. Schons, senior in chemical engineering at the Univ. of Minnesota.

A tour of the new Central Research Laboratories of Minnesota Mining & Manufacturing, and a discussion of the laboratory's role in 3M by John Randall, associate director of the lab, rounded out the evening's events.

—A. J. Madden, Jr.

Tulsa, Okla. Progress begins with creative thought, and creativity is developed not inherited. "Administering to Encourage Creativity," a talk by C. A. Dunn, executive director of engineering research, Oklahoma A&M, held the floor at the Tulsa Section's April 19 meeting.

A major quality of a good administrator today is the desire and ability to encourage the development of new ideas by those who work under him.

Of the four important considerations in the creative thinking process, environment is, perhaps, the most important. A free, unfettered environment where creation can follow its course unimpeded, is a necessity. Full recognition to the creator, material consideration, and proper channelling of related information, are the three other considerations.

For the administrator, there are also four ways to help stimulate creative thinking. (1) Confer on the subject; (2) have confidence in the creator; (3) always be willing to listen; (4) hold creative analysis sessions to hear and debate all possible proposals.

—J. H. Kelly

Baton Rouge, La. Plastic development was the chief topic of J. DeBell, DeBell and Richardson, speaking at the April 13 meeting of the Baton Rouge Section. Fifty members were present.

—K. A. Rees

Houston, Tex. As a feature of its all-day technical meeting in October, the South Texas Section is again presenting its award to the member of the Section who, in the opinion of the Awards Committee, published the best paper during the preceding year.

The idea is designed to encourage the publication of first quality papers.

—J. H. Presnell

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IN MANAGEMENT AND TECHNOLOGY

Ray P. Dinsmore, a director of the A.I.Ch.E., has been chosen to receive the Charles Goodyear Medal for 1955 by the rubber division of the American Chemical Society. Dinsmore is vice-president of research and development for the Goodyear Tire & Rubber Co. The medal is given annually to a person who has made a valuable contribution to the science or technology of rubber or related subjects.

Dinsmore recently was elected president of the American Institute of Chemists.

Roland Voorhees is appointed associate director of development for the chemicals and plastics divisions of Union Carbide and Carbon Corp. with headquarters in New York. He will be primarily concerned with the development of new syntheses and production processes, spending much time maintaining European chemical industrial contacts.

Paul H. Emmett returns to the faculty of Johns Hopkins U. to fill the new professorship to be known as the "Grace Chair of Chemistry," recently established by Davison Chemical Co., division of W. R. Grace & Co. Emmett, on the Johns Hopkins faculty from 1937 to 1944 as chairman of the department of chemical engineering, returns there from his position as senior fellow at Mellon Institute of Industrial Research.

Humble Oil & Refining Co. promotes four chemical engineers.

I. D. Hall and **P. N. Kuehler,** technical associates . . . **Nick P. Peet,** senior technical specialist. All in the technical service division.

C. J. G. Leesemann is research associate in the research and development division.

N. K. Talbert joins Spencer Chemical Co. in the chemical research department.

(*Continued on page* 88)

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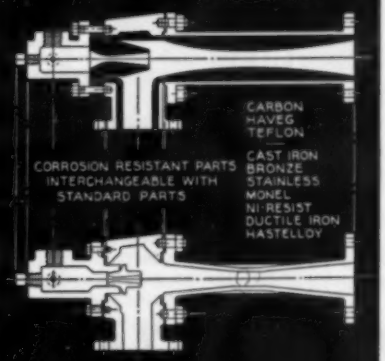

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research is stronger
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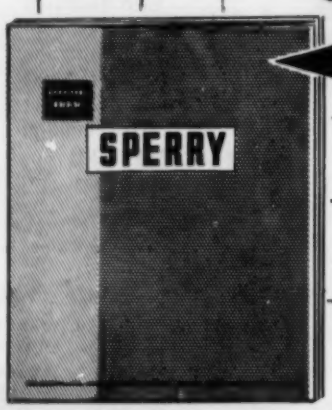

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PEOPLE

(*Continued from page 87*)

R. L. Murray, twice a director of the A.I.Ch.E., becomes chairman of the board of Hooker Electrochemical Co. Murray (pictured here), president of the company since 1951, will "continue to be the company's chief executive officer" according to retiring chairman Edwin R. Bartlett. Bjarne Klaussen succeeds Murray as Hooker's president.

William H. Schuette advances to position of general manager of the Midland division of Dow Chemical Co. He had been in the capacity of assistant to the general manager since January. He has been a chemical engineer with Dow since 1941.

Koppers Co., Inc., names eight to new positions: **Julius Little,** superintendent in the Chicago plant . . . **C. T. Densmore** succeeds Little as superintendent at the Garwood plant . . . **W. E. Cunningham** moves from Chicago to become asst. superintendent of the Seaboard plant. **G. V. McGurl,** new manager, fuels processing section . . . **E. V. Harlow,** assistant manager of this section. **E. H. Dobratz,** manager, high pressure branch with **H. B. Smith, Jr.,** assistant . . . **J. F. Farnsworth,** manager, gasification branch.

Philip M. Dinkins is elected vice-president-operations for the dyestuff and chemical division of General Aniline & Film Corp. Long active in the chemical industry, Dinkins had been president and director of the Jefferson Chemical Co., Inc.

William H. Bowman is appointed assistant general manager, organic chemicals division of American Cyanamid Co. He leaves the post of vice-president of Jefferson Chemical Co.

Murlin T. Howerton will take over the chairmanship of the chemical engineering department of the University of Denver. Howerton comes to Denver from Notre Dame U. where he was professor of chemical engineering.

In recent elections of the American Institute of Chemists, **Donald B. Keyes** becomes chairman of the board of this organization. He previously held the office of president.

Houdry Process Corp. names **Jack Dart** manager of its chemical division. Dart, elected to the board of directors of the company in April previously had held the position of manager of research and development. Houdry names also, **Theodore A. Burtis** assoc. manager of research and development at the Linwood, Pa. labs. Burtis had been supervisor of process engineering. Director of development **Joseph W. Schall** becomes asst. manager of marketing, chemical division of the company. All are engaged in expanded program of the newly established division. (Pictured top to bottom: Dart, Burtis, Schall.)

With 15 years' experience in industry, **J. G. MacDermot** is appointed assistant general manager of the overseas division of Monsanto Chemical Co.

George S. Hannaway is director of marketing for this division.

Ralph N. Lulek announces that he will become a chemical and management consultant. He had been associated with the Grace Chemical Co. in charge of manufacturing and research.

Lulek will continue as a member of the Board of Directors and as consultant to the Grace company.

A. D. Miller is named general manager of the synthetic rubber and latex division recently established in the Firestone Tire & Rubber Co.

Celanese Corp. of America elects **Richard W. KixMiller** vice-president in charge of the chemical division of the company. KixMiller joined Celanese in 1946.

Harry M. Zimmerman is general manager of the plastics division of Seiberling Rubber Co.

A. W. Cash Co., Ill., names **John A. Wiedmann** director of research and development.

(*Continued on page* 91)

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Junior TUBE CLEANERS *for* SMALL TUBES

The new Rotojet Junior Tube Cleaner has unusual power to clean small tubes quickly. This convenient, compact, self-contained cleaner, designed for one-man operation, needs very little headroom. Tube bundles can be cleaned without removal from shell.

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Robert J. Musser is appointed

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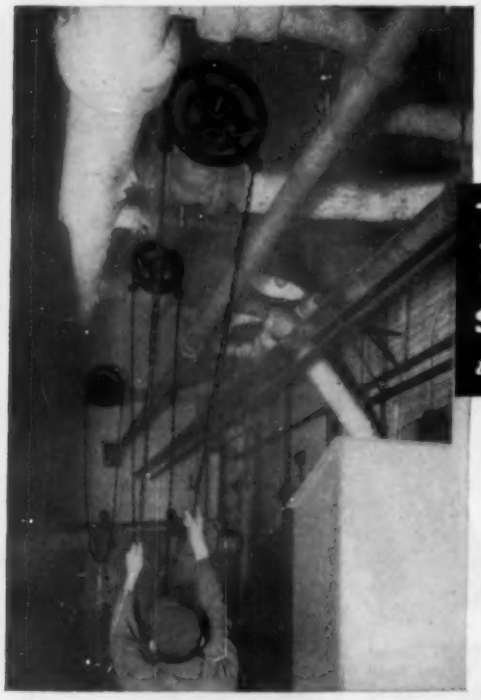

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the chemical engineer in MARKETING

H. D. McLeese takes over as general sales manager of Metal & Thermit Corp. He has served successively as sales engineer, sales manager and vice-president and general sales manager with United Chromium, Inc., division of Metal & Thermit. He will headquarter in New York.

Also, **Henry Mahlstedt** is manager of sales in the electroplating and coating sales department. Mahlstedt has been with Metal & Thermit since 1927.

The Floridin Company appoints **Kenneth K. Krausche** research engineer assigned to sales with headquarters in Tallahassee, Fla. Krausche was most recently connected with Pennsylvania Salt Manufacturing Co. in technical supervising and sales capacities.

Jefferson Chemical Co., Inc., names **J. D. McPherson** vice-president in charge of sales. With American Cyanamid, joint owner of Jefferson, for ten years, McPherson has experience in various capacities including manager of the manufacturers chemicals department.

William V. Sauter, Jr., is new assistant sales manager for neoprene in the elastomers division of DuPont. Sauter had been technical development representative for two years.

In a series of appointments to expand the sales staff of Niagara filters division of American Machine and Metals, Inc., **John M. McConney** becomes assistant applications engineer. He has been with Merck & Co. and in the Army Chemical Center, Md.

Earle D. Moiles, Jr., formerly sales field engineer, is promoted to district manager in Boston for Leeds & Northrup Co., manufacturers of electrical measuring instruments, automatic controls, and heat treating furnaces.

Chemical engineer **C. M. Williams** will headquarter in Chicago as head of this new office to handle Midwest business of the Lithium Corporation of America.

With American Cyanamid since 1940, **R. L. Lambert** becomes assistant manager in the manufacturers chemicals department.

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Robert J. Musser is appointed assistant manager of the market research department of Carbide and Carbon Chemicals Company. He will assist the manager in surveys of future markets for new and established products.

Musser joined Carbide in 1947.

With headquarters in Kansas City, **M. L. Davis** will head industrial sales in four midwest states for the Velsicol Corp. Davis comes to his new position with experience as sales engineer for Nielsen & Fryer.

William J. Davies to district manager of Worthington Corp.'s Cleveland office. He has been with Worthington since 1937.

Robert M. Burford of Pennsylvania Salt Manufacturing Co., transfers headquarters to Pittsburgh to represent the company in the metal processing chemicals department.

In the B-I-F Industries, Inc. expansion program, **M. H. Strickland,** widely known in the petroleum and petrochemical field, takes over as manager of industrial sales in the Chicago area.

PEOPLE

(*Continued from page* 89)

Chemstrand Corp. announces the promotion of **A. A. Nellis** to position of technical superintendent. **Cole Downing** takes over as assistant technical superintendent.

Nellis is vice-chairman of the Tennessee Valley Section of the A.I.Ch.E.

M. Clare Gilchrist joins Phillips Petroleum Co. in the atomic energy division.

Chemical engineers **Eugene F. Berry** and **Arthur W. Brown** also will work with Phillips in this division.

Michael G. Kesler joins staff of the gaseous combustion group, Atlantic Research Corp.

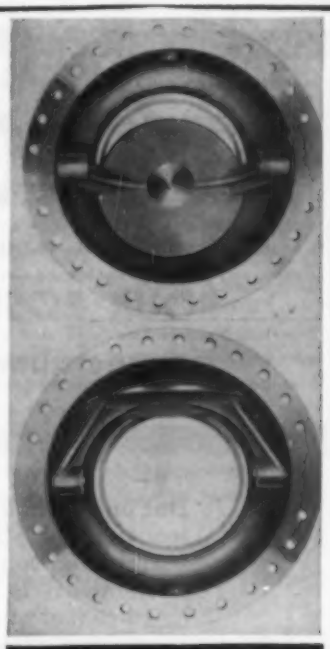
The heat and power division of the National Bureau of Standards announces **Charles M. Herzfeld** as consultant to the chief of the division.

Carl A. vonEnde appointed manager of Cascade Mill, paper manufacturing division of Brown Co., N. H.

Harold Rafson is promoted to project leader in engineering research by General Foods.

Lawrence Lynn added to the staff of central labs as assistant lab director.

(*Continued on page* 96)



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This Gemco Spherical Dust-Tite valve is the only self-cleaning, free flowing, dust-tite valve on the market today. The spherical arrangement, with metal-to-metal contact, is machined to close tolerances for accurate seating. The seat and disc, made to withstand hard and continuous use, rotates in or out of place as shown above, an arrangement that provides positive self-cleaning—and also makes possible a straight-through clear passage for maximum flow of materials. Dust-tite, water-tite, self-cleaning, sanitary, trouble-free. Manufactured in non-ferrous metals, monel, stainless steel and carbon steel. Sizes from 3 to 24 inches.

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DuPont's Engineering Service Division provides consulting service and technical assistance to operating, production, maintenance, design, research, and construction groups in the company. The objectives of the Division are to assist other company units in improving plant efficiency and product quality, in reducing investment and operating cost, and in increasing capacity.

Four openings are immediately available for experienced graduate chemical engineers to provide consulting service to operating plants in the following specialized technical areas:

DRYING & DRYING EQUIPMENT

Desired qualifications will include substantial experience in the practical aspects of drying particulate solids and sheet and fibrous materials. A sound knowledge of the fundamentals of heat and mass transfer is important.

The duties of the position will require a broad and detailed knowledge of mechanical drying equipment and their applications. The position requires a high level of creativeness and skill in evolving unorthodox solutions to practical problems in drying.

WATER

The desirable background will include extensive experience in water procurement and treatment for industrial plants. Knowledge of water treatment plant operation through practical experience is important.

The successful applicant will provide engineering advice to those designing, constructing, and operating company plants on problems involved in the procurement and treatment of industrial water supplies.

INSTRUMENTAL MEASUREMENT OF PROCESS VARIABLES

Position will require substantial experience in research, application, consulting, or devlopment of techniques for measuring process variables.

Duties of the position include application of infra-red and ultra-violet spectroscopy to automatic analysis of chemical process fluids, and application of instruments for measuring viscosity, temperature, pressure, flow, and other process variables.

General responsibilities in the above areas include trouble-shooting, consultation, and start-up assistance.

PETROCHEMICAL PROCESS & EQUIPMENT

Position requires five to ten years' industrial experience in the fields of research and development on petrochemical processes and equipment.

Principal duties will be to provide engineering consultation to research, development, design, and production groups on petrochemical processes and equipment, to make economic process evaluations, to recommend or specify equipment and process for pilot and plant scale operations.

In addition, in each of the following fields, there is available one position comparable in duties and responsibilities to those listed above:

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Please send complete résumé, including details of education and experience, to:

Mr. J. C. Costello, Jr.
Personnel Section, Engineering Dept.

E. I. du Pont de Nemours & Co., Inc.
Wilmington 98, Delaware

CLASSIFIED SECTION

Address Replies to Box Number Care of CHEMICAL ENGINEERING PROGRESS

SITUATIONS OPEN

PROCESS ENGINEERS

Openings for chemical engineering graduates with minimum three years' experience in process plant design. Work involves project engineering, equipment application and selection, translation of process data into new plant design. Applicant should be well grounded in thermodynamics, unit operations, and equipment specifications. The work is interesting, salary and opportunities are attractive; location in Texas. Send résumé to Box 24-7, Chemical Engineering Progress and interview will be arranged.

CHEMICAL ENGINEERS

Experienced, three to six years', chemical engineers interested in process development with a medium sized chemical plant under extensive expansions. Extensive technical work leading to management responsibilities offers a variety of personal opportunities. Excellent living and further educational accommodations.

Areas: Northern Ohio and other state locations.

Submit brief résumé and salary expected. Box 7-7.

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with design, construction and production experience to lead projects through planning, design, construction and start-up operations. Ages 32-38, with a variety of job experiences desirable.

Job is in plant engineering department, working with all divisions (research, development, production, maintenance and purchasing).

Replies will be confidential and should include a recent photograph, together with full details of background, present salary, etc.

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with one to five years' experience in petroleum refining or related activities for staff work primarily in Cleveland, Ohio. Possible employment in Toledo, Lima, or Cincinnati, also.

Applicant should have the following educational background and industrial experience:

Chemical Engineers: B.S or higher degree and experience in development, pilot plant operation, process design, process trouble shooting, refinery process engineering, economic studies, or related work background.

Chemists: B.S. or higher degree and experience in product and process research or development.

Mechanical Engineers: B.S. or M.S. degree and experience in process equipment construction, design, inspection, or maintenance, petroleum product testing and field evaluation, or related work background.

Age range 22 - 32

Salaries commensurate with experience and level in organization. Advance on merit basis.

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Recent graduate or up to two years of pilot plant experience for research and development work. Work involves the development of new organic and inorganic processes as well as improvements in existing processes. Please give complete details of experience and salary requirement to

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Excellent facilities, salaries commensurate with background and experience. Complete employee benefits plan.

Write giving full particulars regarding personal history, experience and salary desired.

Your letter will receive immediate and confidential attention. Write Box 4-7.

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If you have just graduated with a good scholastic record from a recognized chemical engineering curriculum, you will be interested in the vacancies existing in the development department of this chemical producer. Unusual opportunity for interesting and diversified chemical engineering work; young men who have been similarly employed in the past have attained important executive posts in the space of a few years. If you have a good record and possess better-than-average ambition and drive, we invite you to submit a résumé including scholastic standing and salary expectation. This information will be treated confidentially. Box 6-7.

OPPORTUNITIES FOR PROCESS ENGINEERS

Young men with advanced degrees in chemical engineering or five years' experience in process design of oil refining or organic chemical processes. Opportunities directly concerned with evaluation of research projects and design of new process units based on refining and petro-chemical research and development. Write giving education, experience and personal history to Employment Supervisor

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The man should have appreciation of the overall point of view with a high degree of individual initiative coupled with tactful inquisitiveness and persistence, the ability to write concisely, to think objectively, and draw logical conclusions from available facts. He must be able to meet people of higher rank and to obtain their interest and cooperation.

The man will be located in Kansas City but the job involves a reasonable amount of travel. Company paid group and hospital insurance plus retirement plan and educational benefits are available.

All replies will be held in strictest confidence. In the first letter, please send an outline of education, experience and expected salary to:

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Director of Development

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Preferably under 35 with B.S. or M.S. in chemistry or chemical engineering and about three to five years' patent liaison experience. Some research experience also helpful. Please send full information on qualifications and requirements. Replies held confidential. Box 5-7.

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Large multi-plant chemical manufacturer requires a young chemical or mechanical engineer with several years' plant production or power plant experience.

This is your opportunity to affiliate with a company which is the leader in its field and presently expanding. The job provides an excellent opportunity to learn the company's complete operation with good possibilities of achieving higher responsibilities within a reasonably short time.

Please submit a complete résumé of education and experience with past record of earnings and initial salary desired. Also enclose a recent snapshot if available. Box 8-7.

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Project Engineer:

Position involves design, equipment specifications, construction, and operation of small process development units, with associated production of chemicals for field test and market development. Small group which offers opportunity for individual expression and responsibility. BS or MS degree in chemical engineering and 2 to 5 years applicable experience.

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For position in refinery technology group on fuel evaluation and other technical service projects for petroleum refiners. Position offers opportunity for individual expression and responsibility and contact with persons in outside companies. Requires BS or MS degree in chemical engineering and two to five years' experience in commercial fuel manufacture — cracking, reforming, light ends, blending, economic analysis.

Ideal location in suburban Detroit offers wide choice of living conditions. Send résumé of qualifications to:

Ethyl Corporation Research Laboratories

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Attention: Personnel Manager

PROCESS DESIGN SUPERVISOR

To handle preliminary developmental designs and economics as well as final commercial plant designs for medium-size chemical company at its research laboratory location in Austin, Tex. This highly responsible position requires broad, intensive, chemical engineering training, 8-10 years process design experience preferably in heavy organic chemicals, and demonstrated supervisory ability. Give experience, education, personal history and salary expected. All replies will be kept confidential. Write Box No. 2-7.

ASSISTANT PROFESSOR OF CHEMICAL ENGINEERING — appointment September 1955, Ph.D. necessary, salary dependent on experience, opportunity for research and industrial work. Apply to: R. M. Hubbard, Department Chemical Engineering, University of Virginia, Charlottesville, Va.

CHEMICAL ENGINEER—M.S. level with background in diffusional operations. Excellent growth opportunity with research and development organization in the application of ultrasonics to chemical process problems. AEROPROJECTS INCORPORATED, WEST CHESTER, PENNSYLVANIA.

ENGINEER OR CHEMIST—With petroleum refinery experience for a position in sales to the petroleum industry. Familiarity with fluid catalytic cracking processes desirable. Please reply to Box 9-7 stating age, qualifications and salary requirements.

WANTED—Head of chemical engineering department in accredited Midwestern college. Must have appreciable research and teaching experience. Ph.D. necessary. Also need staff members in chemical engineering at instructor and assistant professor level, because of increased enrollments. Box 10-7.

SITUATIONS WANTED

A.I.Ch.E. Members

CHEMICAL ENGINEER—Eleven years' diversified experience in petrochemicals, petroleum refining, synthetic fuels, and ammonia with emphasis on process design, economic evaluations, cost studies, and company diversification activities. Present assignment as assistant to executive at salary of $10,000 per year. Seek position with aggressive oil or chemical company. Box 1-7.

PRODUCTION MANAGEMENT ENGINEERING—M.Ch.E. Age 37, thirteen years' experience includes resident manager of alcohol plant, chief engineer of eight plant organization, assistant to vice president in charge of production. Seeking responsible position in production management or plant engineering. Box 11-7.

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CHEMICAL ENGINEER—Fifteen years' experience chemurgic type processes in production, development, engineering. Five years as chief engineer, two years as plant manager. Box 12-7.

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HEAVY CHEMICALS, PLANT MANAGER—project manager, staff administrative, expert economic studies, responsible numerous cost savings worth over $100,000 annually. Twenty three years in several plants same company. Will consider one year trial basis. $12,000. Box 14-7.

INDUSTRIAL HYGIENE ENGINEER—Age 46, Chemical engineer, with fourteen years' experience as chemist and chemical engineer with equal amount in industrial hygiene, is receptive to change. Presently directs industrial hygiene, all phases. Box 15-7.

CHEMICAL ENGINEER—M.S. Ch.E. Eighteen years with major oil and engineering companies. Seven years' supervision in process design. Strong in petroleum refining and coal conversion. Also experience in natural gasoline, gas processing, petrochemicals, ethylene, ammonia. Economic studies. Box 16-7.

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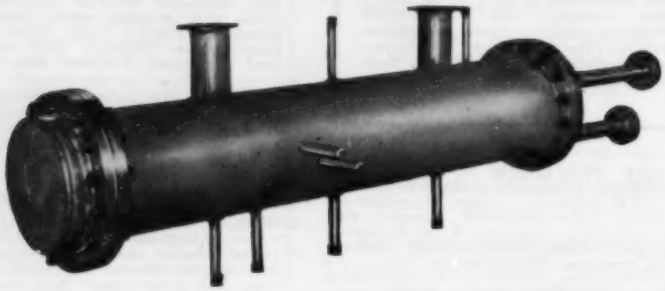
STAINLESS STEEL

for the Chemical Industries



Shell is boiling Genetron-12 at —50F. Fluid enters tubes about 0F and is cooled to —40F or lower. This equipment is unusually suited for Freon; a typical example of Armstrong "adult" engineering to provide Coolers for Chemical Industry needs.

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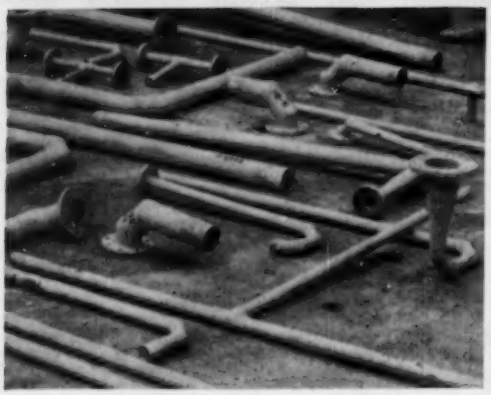

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PEOPLE

(Continued from page 91)

Jesse Coates, with the chemical engineering department of Louisiana State U. since 1936, will take over as head of the department on the retirement this month of Paul M. Horton, who has held the position since 1946. In addition to his university position, Coates is consulting chemical engineer for various companies.

George F. Sharrard is manager of the technical service division of R. M. Hollingshead Corp. Long active in market research and development, Sharrard joins Hollingshead from Chas. Pfizer & Co., Inc.

L. C. Kemp, Jr., is appointed general manager of the recently organized petrochemical dept. of the Texas Co.

Necrology

Chemical Engineering Progress announces with regret the death of the following members of the profession.

I. Arthur Anson, 68, vice-president, Bell Oil & Gas Co., Tulsa, Okla.

Anson became vice-president of Bell Oil & Gas in 1928. He was in charge of design and operation of refineries in the Oklahoma area. Anson has been an active member of the Institute since 1948.

J. Allan Diehr, 25, U. S. Army. Junior process design engineer, Foster Wheeler Corp. previous to induction.

Diehr was elected to junior membership in the Institute in 1953 and had had student member status for two years.

L. Albert Pierce, 40, contract engineer, Otto Construction Corp., New York City.

In 1945, Pierce joined the Woodward Iron Co. in the capacity of asst. superintendent working in by-product coke plant operation. He held this position until he moved to Otto Construction in 1953. He was a member of the Institute since 1944.

Pierce M. Travis, 68, consulting colloid chemist and chemical engineer, Mandel Chemical Products Co., Inc.

Before assuming his last position, Travis had been chemical engineer in charge of emulsion development and secretary of the National Homogenizer Corp.

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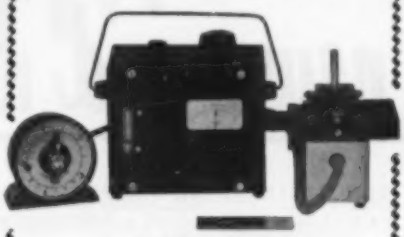
FOR ACCURATE
DUST SAMPLING
FOR PERMANENT RECORDS



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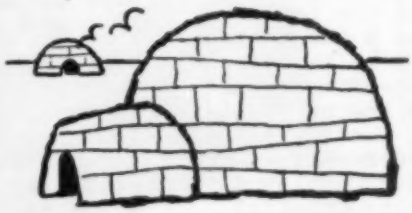

C-R CHILL-VACTOR units flash cool water, aqueous solutions and certain other liquids to temperatures down to 32° F. by partial evaporation at high vacuum.

As with all Croll-Reynolds equipment, the process is very simple. No chemical refrigerant is used. There are no moving parts. First cost as well as operating cost is usually less than for mechanical refrigeration.

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news and notes

NEW ENGINEERING CENTER All five engineering societies have now acted on the report of the Five Presidents, which was reviewed in the March issue . . . Action of the A.I.Ch.E. was reported in June News & Notes . . . To summarize the decision of the other engineering societies, the Electrical Engineers voted to approve the report; the Civil Engineers recommended a task committee of the Committee of Five Presidents plus two additional members from each society & a paid secretary to study locations, the costs to be defrayed by a sum of $75,000 to be appropriated by the five societies. . . . In the meantime another proposition was received from a joint committee headed by Mervin J. Kelly, president of the Bell Telephone Labs. . . The proposal, signed by twenty-one leaders of industry & education, urged that an independent management or engineering firm be employed to coordinate & evaluate all the site studies already made for the Engineering Center & offered that some of those who signed the letter would underwrite the cost of such a survey . . . In addition the signatories of the letter assured the five societies & the United Engineering Trustees that a well-organized, diligent, & competent effort would be made to raise funds for the new Engineering Center . . . Among those who signed were Crawford H. Greenewalt, president of the Dupont Co.; Charles A. Thomas, president of Monsanto Chemical Co.; Robert E. Wilson, chairman of the board of Standard Oil Co. of Indiana; Horace P. Liversidge, chairman of the board of the Philadelphia Electric Co., & many others . . . This new offer caused the Mining, Metallurgical & Petroleum Engineers to vote that they would take advantage of the offer & would hold in abeyance any action on Pittsburgh . . . The Mechanical Engineers were the last to meet--on June 20--& their action followed closely that of the Civils except that they urged a task committee of twenty members & requested that said committee recommend a location for the Engineering Societies Center not later than January 1, 1956, that Pittsburgh be asked to extend its offer to March 1, 1956, that the task committee employ its own chairman & paid secretary & engage its own professional consultants; that $75,000 be appropriated by the five societies, & that the committee be empowered to take advantage of the offer transmitted by Dr. Kelly . . . All this is equivalent to five separate actions by the five societies & the problem from here on will be to get uniformity of opinion on what action should next be taken . . . Since most boards are adjourned for the summer & since the actions of the Civil & Mechanical Engineers call for appropriations of $15,000 from each society, some sort of steering body seems needed.

NUCLEAR CONGRESS A huge Nuclear Congress is going to be held in Cleveland, Ohio, December 12-16 . . . A.I.Ch.E. is one of the twenty-seven engineering & scientific groups sponsoring the congress, which will be coordinated by Engineers Joint Council . . . A.I.Ch.E. Council offered to underwrite the program, premeeting publicity, & preprints for the Congress & this was accepted by the Engineers Joint Council . . . A.I.Ch.E. is also the sponsor of an Atomic Exposition to be held the same week in Exposition Hall in Cleveland . . . This is all an outgrowth of the Nuclear Congress & Exposition held last year in Ann Arbor by the A.I.Ch.E.

STANDARDS FOR COOLING TOWERS Standards for cooling towers will be studied by a subcommittee of the Chemical Industry Advisory Board of the American Standards Association . . . Chairman of the subcommittee is V. W. Haedrich of Dupont Co. & A.I.Ch.E. alternate representative on the Chemical Industry Advisory Board . . . The committee after studying current activities of all the various groups concerned with developing standards & test procedures, performance, specifications, materials, dimensions, etc., of cooling towers will make recommendations.

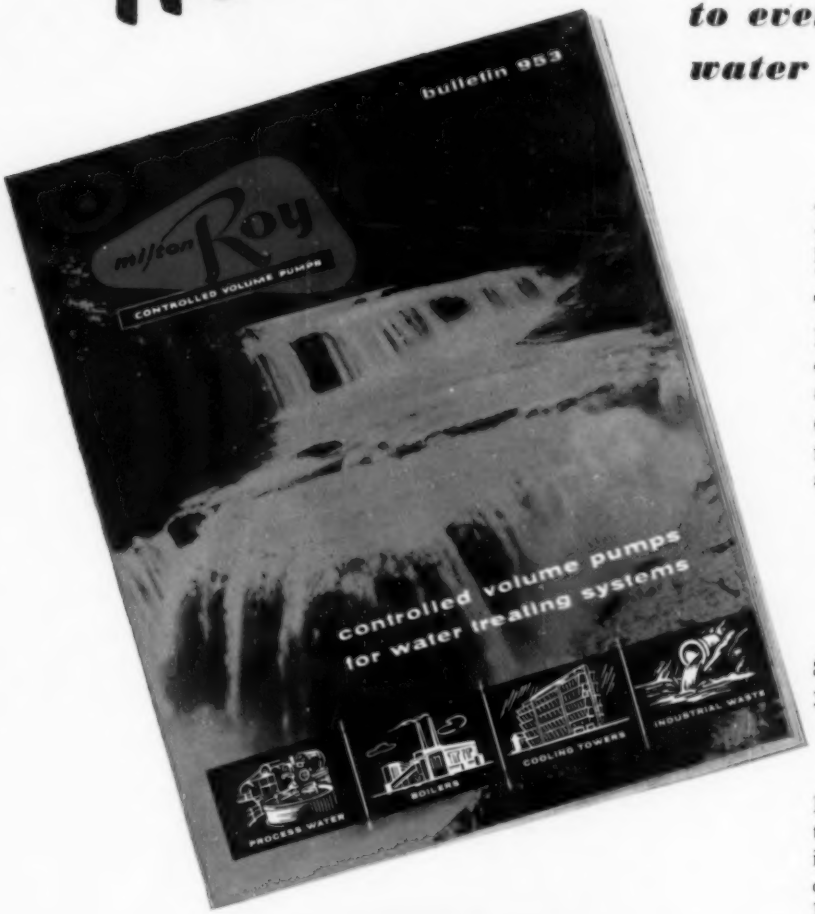
PRESIDENTIAL SPEAKING TOUR President Dodge is arranging a speaking trip through the west for next September to hit as many local sections as he can . . . Speaking load on the A.I.Ch.E. president can be quite heavy, as many local sections avail themselves of the willingness of our elected officers to speak . . . Last year Kirkbride spoke twenty-five times before local sections, student chapters, etc. . . & Professor Dodge has already presented his talk on "Energy Resources" many times this year.

F.J.V.A.

This

NEW BULLETIN

provides economical solutions to every industrial water treatment problem



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It has been termed, "a most important contribution to water treating literature."

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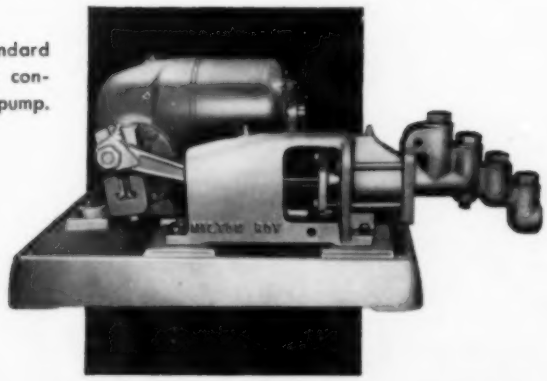
For specific recommendations on water treatment problems, see your consulting specialist. For reliable, accurate flow control of water treating chemicals, see Milton Roy Company, Manufacturing Engineers, 1300 East Mermaid Lane, Philadelphia 18, Pa.



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No guesswork

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This is because MIXCO engineers are uniquely equipped to pilot-plant your operation, using standard calibrated mixing impellers with *fully-known power characteristics.*

There's no guesswork. Scale-up is accurate. Every LIGHTNIN Mixer is guaranteed, unconditionally, to do the job for which it is recommended.

That's just one reason—and a powerful one—why chemical and pharmaceutical leaders, such as Eli Lilly, more than ever, are standardizing on LIGHTNIN Mixers for *every* fluid mixing operation.

Want to know, specifically, how you can be sure of optimum fluid mixing? Your LIGHTNIN Mixer representative will be glad to show you. His name is in your copy of Chemical Engineering Catalog. Why not phone him today?

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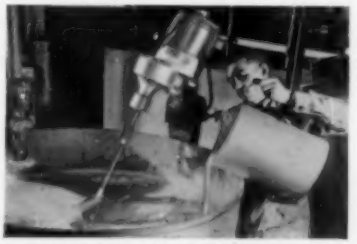

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